The Engineer

UNIVERSITY OF MICHIGAN
APR 27 1953
ENGINEERING LIBRARY

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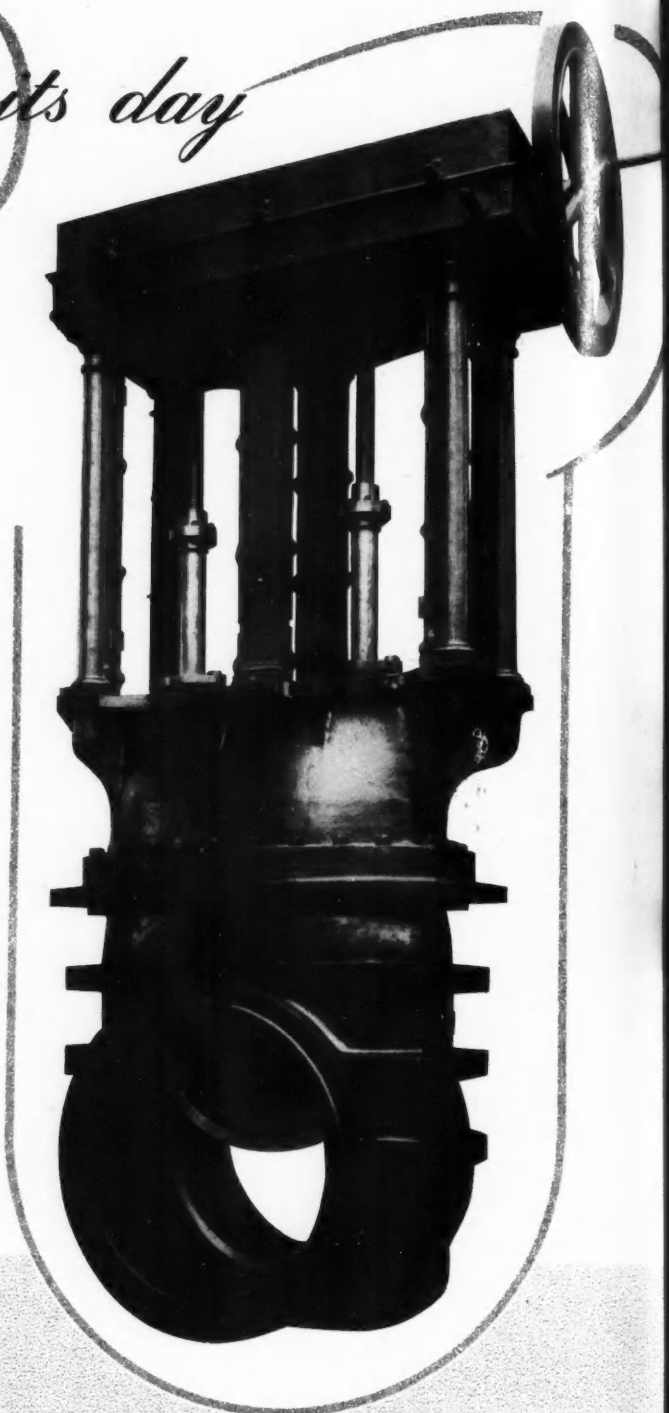
Howden Centicell
dust collectors
at a London Power Station

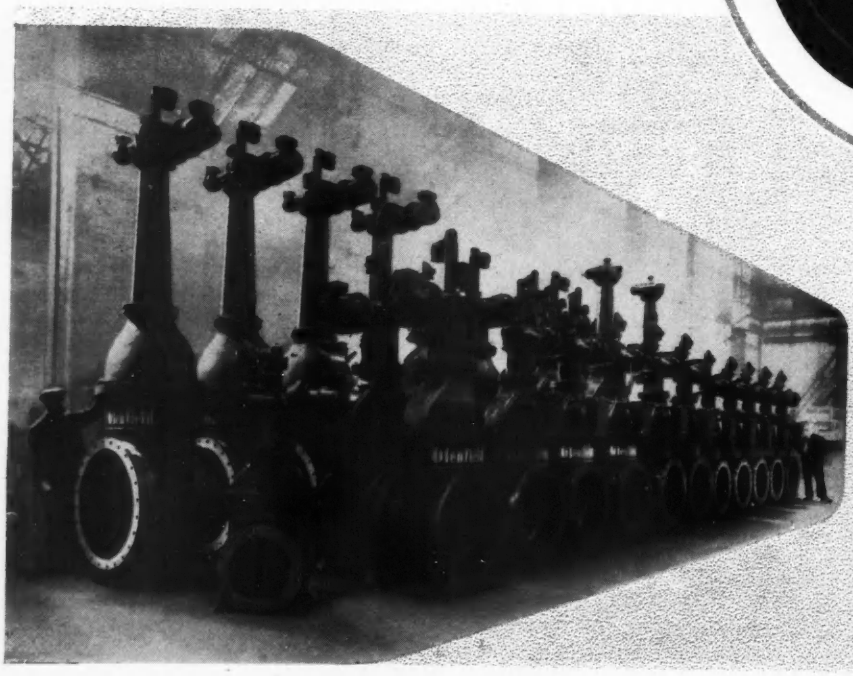
JAMES
HOWDEN

JAMES HOWDEN & COMPANY LIMITED, 195 SCOTLAND STREET, GLASGOW, C.5 AND 15 GROSVENOR PLACE, LONDON, S.W.1

A fine valve on its day 1890

One of many early Glenfield Sluice Valves, the design and manufacture of which contributed much towards the hundred years' experience which is now behind the production of every Glenfield Valve.





Glenfield

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Head Office and Works: KILMARNOCK, SCOTLAND

BOMBAY: KHETAN BHUVAN, 198 JAMSHEDJI TATA ROAD, CHURCHGATE RECLAMATION. P.O. BOX

CALCUTTA: FAIRLIE HOUSE, FAIRLIE PLACE. P.O. BOX

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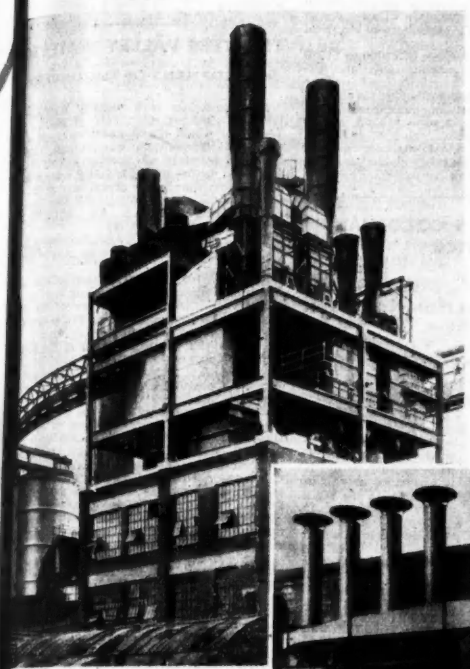
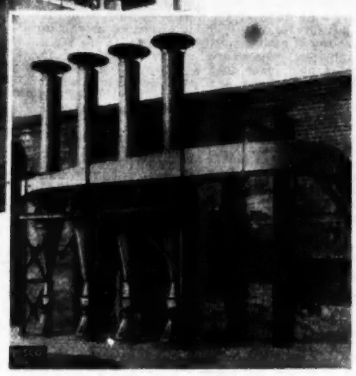
DUST COLLECTION
for every Industry.





o-Beth" Automatic Dust Collector
compartments for recovering finely
ed soap powder.

4 "Visco" High Efficiency Cyclones for recovering dust produced by tool grinding process at a Sheffield Steel Works.

In almost every industry whose products are in powder form, the installation of "Visco" Dust Collecting equipment has resulted in eliminating waste, and keeping factories and their vicinities free from dust.

When the product is a fine dust—such as soap powder, cement, chemicals, etc.—a "Visco-Beth" Automatic Collector is most suitable. This will operate for long periods at full load with minimum unskilled attention at practically 100% efficiency.

For the recovery of coarser materials, as granite chips, limestone dust, dried grass, "Visco" High Efficiency Cyclones are admirable. These have a recovery efficiency up to 95%.

Repeatedly, it has been proved that it pays to collect dust liberated during grinding, conveying, packing and other processes; even when the material has only slight commercial value.

Consult us on your Dust Problem.

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ENGINEERING CO LTD
STAFFORD ROAD. CROYDON.

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MAKERS OF AIR FILTERS, WATER COOLERS AND AIR CONDITIONING PLANT

THE ENGINEER

ESTABLISHED 1856

Vol. 195 No. 5071

APRIL 3, 1953

28 Essex Street, Strand, London, W.C.2

Telephone: CENtral 6565 Telegrams: Engineer Newspaper, Estrand, London

Published every Friday Registered as a Newspaper

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NOTICE TO READERS
All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the firs. 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

THE UNIVERSITY COLLEGE OF KHARTOUM

SUDAN

LECTURESHIPS OR ASSISTANT LECTURESHIPS

Applications are invited for appointment to TWO LECTURESHIPS or ASSISTANT LECTURESHIPS in the Faculty of Engineering: Civil Engineering, Mechanical Engineering.

Salaries on scale: Lecturer £E.1150 by £E.75 to £E.1525 p.a.; Assistant Lecturer £E.950 to £E.1000 to £E.1075 p.a. Status and point of entry in scale according to qualifications and experience. Cost of living allowance at present £E.144 p.a. Outfit allowance £50 on first appointment. Paid passages for member of staff and assisted passages for family on appointment, termination and leave (each long vacation after the first). No income tax payable at present in the Sudan. £E.=£1 0s. 6d.

Applications (eight copies), giving full details of qualifications and experience and the names of three referees should be sent to the Secretary, Inter-University Council for Higher Education in the Colonies, 1, Gordon Square, London, W.C.1, from whom further information may be obtained. Closing date, 20th April, 1953. E8055

UNIVERSITY OF MELBOURNE

AUSTRALIA

SENIOR LECTURER IN HYDRAULIC ENGINEERING

Applications are invited for a position of SENIOR LECTURER IN HYDRAULIC ENGINEERING.

Salary: £A1234 to £A1484 per annum (including £A234 cost of living allowance), commencing salary according to qualifications. Superannuation is similar to F.S.S.U.

Duties: Teaching, research and other work in Hydraulic Engineering, including design work for new laboratory.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1.

The closing date for the receipt of applications in London and Australia is 18th May, 1953. E7882

THE UNIVERSITY OF MANCHESTER

LECTURER IN ENGINEERING

Applications are invited for the post of LECTURER IN ENGINEERING. Candidates should have qualifications in Civil Engineering, with special interests in Structures or Hydraulics. Salary scale, £500–£1100 per annum, with membership of F.S.S.U. and Children's Allowance Scheme. Initial salary according to qualifications and experience. Applications should be sent not later than 25th April, 1953, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained. E7954

THE NORWICH CITY COLLEGE AND ART SCHOOL,

IPSWICH ROAD, NORWICH

Principal: FRANK BRIERS B.Sc., D.Phil. (Oxon)

TEACHER OF MECHANICAL ENGINEERING

Wanted, for September 1st, TEACHER of MECHANICAL ENGINEERING SUBJECTS for day and evening classes, including some work in the Higher National Certificate course and possibly some B.Sc. work. Applicants should hold a Degree or possess an equivalent qualification, have had industrial experience and be Corporate Members of the Institution of Mechanical Engineers or the Institution of Production Engineers.

Salary in accordance with the Burnham Scale for Teachers in Establishments of Further Education, Grade B (£490 by £25 to £765 per annum, together with approved allowances).

Application forms, which may be obtained from the Director of Education, City Hall, Norwich, on receipt of a stamped addressed envelope, should be returned to the Principal. E8018

UNIVERSITY OF BELFAST

LECTURESHIP IN CIVIL ENGINEERING

The Senate of the Queen's University of Belfast invites applications for a LECTURESHIP in CIVIL ENGINEERING from 1st October, 1953. A special interest in hydraulics would be an advantage. Salary range £800 by £50 to £1150, with contributory pension rights under the F.S.S.U. Initial placing on the scale will depend on experience and qualifications. Applications should be received by 15th May, 1953.—Particulars from G. R. Cowie, M.A., LL.B., Secretary. E8020

BRITISH ELECTRICITY AUTHORITY

SOUTH-EASTERN DIVISION

MAINTENANCE ENGINEER (MECHANICAL)

MAINTENANCE ENGINEER (Mechanical) at Kingston "B" Power Station. Applicants should preferably possess B.Sc. Degree or equivalent or be Corporate Members of the Institution of Mechanical Engineers, and must have had experience in the control of labour. Extensive experience in the maintenance of high-pressure turbine and boiler plant and power station auxiliaries essential. N.J.B. conditions of service. Class G, Grade VI, £826 7s. p.a., including London allowance.—Applications, giving details of education, present position, experience, &c., should be sent to the Station Superintendent, Kingston "B" Power Station, Downhall Road, Kingston-upon-Thames, Surrey, to arrive by 11th April. E8004

PUBLIC APPOINTMENTS

CIVIL SERVICE COMMISSION

H.M. DOCKYARD TECHNICAL COLLEGES

ASSISTANT MASTERS

The Civil Service Commissioners invite applications from MEN for permanent appointments (about 12 Science and 1 Arts), commencing as soon as possible. Candidates must have, or obtain by September, 1953, a University Degree (or equivalent qualifications). Qualifications in mathematics, physics or engineering (electrical or mechanical) required for the science posts; candidates for the arts vacancy should be qualified to teach one or more of the following subjects:—English, French, certain amount of modern history, economics, current affairs. Burnham Scales for Technical Colleges apply; posts are pensionable under C.S. Superannuation Acts on non-contributory basis.

Details and application forms from Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 4198/53; completed forms to be returned by 30th April, 1953. E8040

FIFE COUNTY COUNCIL

COUNTY ENGINEER'S DEPARTMENT

ENGINEERING ASSISTANT

Applications are invited for appointment as ENGINEERING ASSISTANT at the County Buildings, Cupar. Salary grade, £480, rising by £20 to £600 per annum. Applicants should be qualified Civil Engineers with experience in the design, construction and maintenance of water works and/or drainage works. The successful candidate, if under 45 years of age, will be considered for admission to the council's superannuation scheme subject to a satisfactory medical report being received. Consideration may be given to meeting housing requirements. Applications, stating age, qualifications and experience, with copies of not more than three recent testimonials, to be lodged with the undersigned within ten days of the appearance of this advertisement. No canvassing.

MATTHEW POLLOCK,
County Clerk.

County Buildings,
Cupar—Fife.
26th March, 1953. E8041

TRENT RIVER BOARD

APPOINTMENT OF TWO ENGINEERING ASSISTANTS

Applications are invited for the appointment of TWO ENGINEERING ASSISTANTS, one at the Board's Head Office, Nottingham, and the other at the Board's Divisional Office at Gainsborough.

The salaries will be within A.P.T. Grades I to V (a) (£465–£685 per annum) of the National Scheme of Conditions of Service, according to experience and qualifications.

Preference will be given to candidates who have had experience in land drainage works. Successful candidates will be employed on the design and execution of extensive river improvement works.

Applications, with full particulars, including copies of testimonials or the names of referees, must reach the Engineer to the Board, Trent River Board, 206, Derby Road, Nottingham, within fourteen days of the date of the publication of this advertisement.

JOHN HIRST,
E7930 Clerk of the Board.

BRITISH ELECTRICITY AUTHORITY

EASTERN DIVISION

DRAUGHTSMEN (MECHANICAL)

Applications are invited for the following appointments in the Generation (Construction) Department at Divisional Headquarters:—DRAUGHTSMEN (MECHANICAL).

Salary, Grades 4–6, £458–£819 per annum.

The commencing salary (which includes London weighting) will depend upon experience and qualifications, but will be within the above range.

Applicants should preferably have experience in generating station plant layout and design of pipework, coal, ash and dust handling systems.

Applications, stating age, qualifications and experience, should be sent to the Divisional Controller, British Electricity Authority, Eastern Division, Northmet House, Southgate, N.14, by 18th April, 1953.

W. N. C. CLINCH,
E8027 Controller.

BRITISH RAILWAYS

RESEARCH DEPARTMENT (ENGINEERING DIVISION)

SCIENTIFIC OFFICERS, GRADE I

Railway Executive.—Vacancies exist in the Research Department (Engineering Division) at Derby for SCIENTIFIC OFFICERS, Grade I (£778–£850) and Grade II (£478–£752). Candidates must possess a good Honours Degree in Engineering or Mathematics and some research experience in either mechanical or civil engineering is essential for the Grade I post.

Superannuation fund and certain free travel facilities.

Applications to Director of Research, 222, Marylebone Road, London, N.W.1. E8022

PUBLIC APPOINTMENTS

NATIONAL COAL BOARD

MECHANICAL AND ELECTRICAL ENGINEERING BRANCH

CONTROL AND SWITCHGEAR ENGINEER

National Coal Board invite applications for a superannuable appointment as CONTROL and SWITCHGEAR ENGINEER in the Mechanical and Electrical Engineering Branch at London Headquarters.

Although primarily concerned with control and switchgear, the successful candidate will be expected to do other general electrical work. Preference will be given to applicants with some or all of the following qualifications and experience: eligibility for Associate Membership of the Institution of Electrical Engineers; experience at a manufacturers' works on design, manufacture and application of all types of mining electrical apparatus; experience of electrical engineering at a coal mine.

The salary will be within a range of £1000 to £1250 per annum, according to qualifications and experience.

Apply in writing, giving full particulars (in chronological order) of age, education, qualifications and experience (with dates) to National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, marking envelope TT/613. Original testimonials should not be forwarded. Closing date 30th April, 1953. E8013

HER MAJESTY'S COLONIAL SERVICE

DEPARTMENT OF WATER DEVELOPMENT IRRIGATION, NORTHERN RHODESIA

WATER ENGINEERS

Applications are invited for the following posts:—WATER ENGINEERS, Department of Water Development Irrigation, Northern Rhodesia.

Appointment is on probation for permanent and pensionable establishment. Salary in the incremental scale £655–£1320, plus temporary, variable, non-pensionable, cost-of-living allowance at rate of 24 per cent of basic salary (maximum £316 16s. p.a.).

Candidates, who should be between 25 and 45 years of age, must hold a recognised University Degree or Diploma in Civil Engineering, which carries exemption from Sections I and II of the A.M.I.C.E. examinations, plus two years' approved practical experience, or be A.M.I.C.E. Duties will include design and supervision of construction of irrigation works and development of water resources.

Full details available on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 140/3/01. E8037

CITY OF LEICESTER

WATER DEPARTMENT

JUNIOR CIVIL ENGINEER

JUNIOR CIVIL ENGINEER required by Water Department of the City of Leicester, to assist in the design and construction of works of water supply, including aqueducts, service reservoirs and the development of a new source of supply. The appointment is a permanent one and the salary lies within the range A.P.T. I-IV (£465–£600 per annum), depending upon qualifications and length of experience.

Applicants should have passed Sections A and B of the Institution of Civil Engineers Examination or should hold an exempting degree. Practical experience, particularly of works of water supply, is desirable but not essential.

The appointment is subject to the provisions of the Local Government Superannuation Act, 1937, and to a satisfactory medical examination.

Applications giving full details of training and experience should be submitted to the undersigned before 11th, April 1953.

HAL WALLHOUSE,
Engineer and Manager.

City of Leicester Water Department,
Bowling Green Street,
Leicester. E7943

BRITISH ELECTRICITY AUTHORITY

PRODUCTION, INSPECTION AND TEST SUB-BRANCH

THIRD ASSISTANT ENGINEER (ELECTRICAL)

British Electricity Authority, Production, Inspection and Test Sub-Branch, require a THIRD ASSISTANT ENGINEER (Electrical) in the Manchester Regional Office. Candidates should be Graduate Members of the I.E.E. or hold equivalent qualifications. Recent first-hand experience of production methods, test and inspection work in manufacturers' works in connection with plant and equipment for modern power stations is essential, and some experience of constructional and plant erection work at power stations and attendance at site progress meetings would be an advantage. Salary N.J.B., Grade 4, £717–£934.

Applications, stating age, qualifications, experience, and salary, to D. Moffat, Director of Establishments, Winsley Street, London, W.1, by April 18th, 1953. Quote reference AE/354. E8017

PUBLIC APPOINTMENTS

MINISTRY OF SUPPLY

ROYAL AIRCRAFT ESTABLISHM

MECHANICAL ENGINEER OR PH

Ministry of Supply, Royal Aircraft Estab Farnborough, Hants, requires MECH ENGINEER or PHYSICIST, to undertak mental and theoretical work with light mec First or Second Class Honours Degree or e in Mechanical Engineering or Physics. experience an advantage. Salary within Scientific Officer, £417–£675; women s less. Post unestablished. F.S.S.U. benefits available.—Application forms from M.O. Technical and Scientific Register (K), 2 Street, London, S.W.1, quoting C169/53A. date 25th April, 1953.

TENDERS

THE TEES VALLEY WATER B

DEVELOPMENT OF THE UNDERTA

In connection with certain WORKS DEVELOPMENT OF THE WATER U TAKING which the Board proposes to ca conditions of contract, specifications, bills o tities and drawings will shortly be ready for scheduled below and TENDERS are invi Contractors thoroughly experienced in such CONTRACT No. 38: FILTRATION PUMPING WORKS AT BROKEN NEAR DARLINGTON.

The Construction, Completion and Main in thorough repair for twelve months fro pletion of:—

Bill No. 1: Superstructure of the L Pumping Station and Surge Tank Building.

Bill No. 2: Superstructure of the Hi Pumping Station and Sludge Pump House Works.

Bill No. 3: Superstructure of the Tra House Block.

Bill No. 4: Superstructure of Chemical Block; Construction of Heating Chamber Store.

The whole of the work will be let as one Co

Contractors who are desirous of Tender the above-mentioned works should apply in to T. S. R. Winter, Esq., M.I.C.E., Engin General Manager, The Tees Valley Water Corporation Road, Middlesbrough, indicating are interested and enclosing the amount of deposit. Cheques to be made payable to "T Valley Water Board." The Deposit will be re upon the submission of a bona-fide Tender return of all the documents and drawings.

Tenders, in plain, sealed envelopes, bear means of identification, endorsed "Contra 38," and addressed to "The Chairman of the B at the undermentioned address, shall be recei later than 10 a.m. on Monday, the 11th May,

The Board does not bind itself to accept the or any Tender.

E. A. MORR
Water Board Offices, Clerk of the B
Corporation Road,
Middlesbrough,
March, 1953. E

BOROUGH OF LEYTON

AUCKLAND ROAD DEPOT

TRADE WASTE CONVEYOR

TENDERS are invited for the CONSTRUC and ERECTION of a TRADE WASTE VEYOR capable of handling 20 cubic yar hour of trade waste.

Tender documents may be obtained fro Borough Engineer and Surveyor on payment deposit of £2 2s., returnable on receipt of a bo Tender.

Tenders, enclosed in the official envelope, m delivered to the undersigned not later than noon on Thursday, 11th June, 1953.

D. J. OSBORNE,
Town Hall, Town C
Leyton, E.10,
25th March, 1953. E

INDIA STORE DEPARTMEN

PLANING MACHINE

The Director-General, India Store Depar 32/44, Edgware Road, London, W.2. TENDERS for the SUPPLY of:—

Plate Edge PLANING MACHINE, electric driven, capable of planing edges of mild steel up to 20ft. long and up to 1¼in. thick, wit adjustment to deal with packs of plates up t deep. No. 1.

Forms of Tender, which are returnable by 15th May, 1953, may be purchased at the address at a cost of 10s.

Reference number S.5625/50 should be quo all applications. E

INDIA STORE DEPARTMEN

WHEELS AND AXLES

The Director-General, India Store Depar 32/44, Edgware Road, London, W.2, invites TENDERS for the SUPPLY of:—

WHEELS AND AXLES for 10-ton axle carriage. Metre gauge. Completely assembled rolled steel disc wheel centres, tyres 2ft 4½ on tread, glut rings and axles with 7in. by journals to I.R.S. Drawing No. WA.42, and to I.R.S. part drawings mentioned thereon.

Tenders will be required to be kept open period of 60 days.

Forms of Tender, which are returnable by 15th May, 1953, may be purchased at the address at a cost of 10s. each.

In all applications for Tender forms the Ref S.6743/52/RLY.2 must be quoted. E

THE ENGINEER

APRIL 3, 1953

Lord Weir's Gifts to Institutions

DURING the last week announcements have been made by five British engineering institutions concerning gifts of £10,000 which have been made to each of them by Lord Weir, P.C., chairman of G. and J. Weir, Ltd., Cathcart, Glasgow. The five institutions which have received these generous gifts are the Institution of Mechanical Engineers, the Institution of Naval Architects, the Institute of Marine Engineers, the North-East Coast Institution of Engineers and Shipbuilders, and the Institution of Engineers and Shipbuilders in Scotland. In making his gifts, Lord Weir has intimated to each Institution that he desires the money to be used to benefit its work in any useful direction or form of activity according to the discretion of the council. For many years Lord Weir has participated in the work of these institutions. He is a past vice-president and honorary member of the Institution of Mechanical Engineers, an honorary vice-president of the Institution of Naval Architects, a past-president of the Institute of Marine Engineers, a member of the North-East Coast Institution of Engineers and Shipbuilders, and the senior honorary member of the Institution of Engineers and Shipbuilders in Scotland.

Institution of Mechanical Engineers

AT the annual general meeting of the Institution of Mechanical Engineers, which was held in London on Friday last, March 27th, Mr. Alfred Roebuck was elected president in succession to Sir David Pye, C.B. Mr. Roebuck is a director of Hadfields, Ltd., Sheffield, with which firm he has spent the whole of his engineering career to date. He is also a director of John Baker and Bessemer, Ltd., and Millspaugh, Ltd. Mr. Roebuck is an honorary member of the council of the Iron and Steel Institute and a past-president of the Junior Institution of Engineers. He was elected to membership of the Institution of Mechanical Engineers in 1929, and served as chairman of the Yorkshire branch in 1938 and 1939. Other elections announced at the meeting were : vice-presidents, Dr. R. W. Bailey and Sir Ewart Smith ; members of council, Mr. H. Desmond Carter, Dr. D. F. Galloway, Professor E. Giffen, Sir Kenneth Hague, Air Marshal R. O. Jones, Mr. R. A. Riddles, and Mr. R. Stewartson. The other members of the Institution's council for the ensuing year are Sir David Pye, Mr. A. C. Hartley, Dr. S. F. Dorey, and Dr. H. J. Gough, all of whom are past-presidents, the chairmen of the eleven local branches of the Institution, and the chairman of the automobile division, Mr. Maurice Platt.

Institute of Marine Engineers' Annual Report

THE annual report of the Institute of Marine Engineers mentions that 1952 has been particularly important in that the foundations have been laid of several policies which, it is expected, will benefit the Institute. It has been decided to investigate the formation of local sections at a number of ports, and the report notes the year's operations at Cardiff, Kingston-upon-Hull and Sydney. Membership is shown to have increased again, particularly in the junior membership, the overall total standing at 7095 on December 31, 1950, which is an increase of 384 over that of the previous year. There is a list of the papers read and discussed during 1952 and also a list of those published in the *Transactions*, together with a record of the junior lectures delivered and the activities of the local sections. It is noted that the second report of the Tonnage Laws Committee has been received and commented upon, and it is evident from the report of the council that the many committees have had a busy year. An account is given of the research items in the programme of the British Shipbuilding Research Association, with particular reference to ship's machinery. There is a reference to the work of the British Electrical and Allied Industries Research Association with notes upon molybdenum steel steam piping and steels for high temperatures.

Institution of Naval Architects' Annual Dinner

ON Wednesday, March 25th, the annual dinner of the Institution of Naval Architects was held at the Connaught Rooms, London, and was attended by nearly 900 naval architects and their guests, with the president, Viscount Runciman of Doxford, as chairman. In the unavoidable absence of the principal guest, Viscount Alexander of Tunis, the Minister of Defence, who was to have proposed the toast of "The Institution of Naval Architects," his speech was read by Captain Duckworth, R.N. (Ret.), the secretary of the Institution. In his speech Viscount Alexander emphasised that the Royal and Merchant Navies were fundamental to our security and that he did not believe that air transport would supersede sea transport ; both methods, he felt, were complementary. He went on to express the Government's appreciation of the part played by shipping in the balance of payments, and noted with concern the reduction in British tonnage and the increase in the tonnage owned abroad. The tonnage figures, he said, indicated the competition to be faced and the importance of constant research. Viscount Runciman, in his reply, considered the problems of the measures for the defence of merchant ships, which, however effective in wartime, were not good in peacetime, and wondered how far it was proper, or even possible, to sacrifice commercial advantages for the sake of added security. The application of higher speed was strictly limited, since British shipping services had to be run at profit and not, as in certain countries, at a loss which was made good by the taxpayer. The president said that the nation must have ships, but must reduce the amount of material, man-hours and capital equipment to produce them or the consequencies may be serious. Mr. E. L. Champness proposed the toast of "The Guests," and Mr. C. C. Black, the chairman of the Liverpool Steam Ship Owners' Association, responded.

A Simple Theory of Suspension Bridges

ON Thursday, March 26th, a paper with the above title was presented to the Institution of Structural Engineers by Professor A. G. Pugsley, who pointed out that, in spite of the growing importance of suspension bridges for long spans, most English textbooks on the theory of structures either made no reference to suspension bridges or else gave only a brief account of Rankine's approximate theory. However, the paucity of English material on the subject was, he contended, more apparent than real. For the analysis of a particular bridge under a particular system of loading there were available at least three alternative methods of approach—the differential equation treatment of the deflection theory, the successive approximation treatment of the relaxation theory, and the simultaneous linear equation approach of the flexibility coefficient method. But none of these improved and more accurate methods made for ready design generalisations, and although they represented successive improvements in the physical understanding of the behaviour of suspension bridges, none had the simplicity and the design appeal of the early theory of Rankine. It was with this background in mind, and in the course of working on the development of the flexibility coefficient approach, that Professor Pugsley had conceived the simple approximate theory outlined in his paper. Essentially, he pointed out, a suspension bridge consisted of two structures—a heavy cable and a beam—both of which were separately capable of carrying transverse loads, but with very different deflections, and their joint behaviour largely depended upon their relative stiffness under transverse loads. Rankine assumed that in practice this relative stiffness would be such that no changes of shape in the cable form would occur ; but, Professor Pugsley asked, were practical bridges really in this category ? And, if not, what were the effects of changes of relative stiffness ? These were the main questions to which, in his view, a simple theory—if it was to improve on Rankine's method—had to provide an answer. In the first section of his paper the place of the relative stiffness of beam and cable, and the natural mode of its expression, were examined by dimensional theory. Thereafter, an analogy was drawn between a beam supported by a cable and a beam supported by an elastic foundation, and a whole field of simple analysis for the latter thereby made available for the former ; the stiffness parameter of dimensional theory was thus brought to effective use. This fact was then illustrated by applying the method to examine a typical bridge, first as regards the girder bending moment problem upon which attention had been primarily concentrated, and then as regards the tensions in the cable and suspension rods. A final section of the paper examined briefly the relevance of the method to the prediction of the natural frequencies of a suspension bridge in flexure.

The Association of Consulting Engineers' Dinner

THE annual dinner of the Association of Consulting Engineers was held at the Dorchester Hotel on Wednesday, March 25th. The toast of "the Association" was proposed by Mr. A. E. Marples, the Parliamentary Secretary, Ministry of Housing and Local Government. In reply to the toast, Sir Bruce White, chairman of the Association, spoke of a number of problems facing the consulting engineer to-day. He said that in some countries the method of dealing with large engineering works, whereby contractors and consultants could prepare a scheme in collaboration, differed from that followed in this country. He remarked that the Association had had talks with the Federation of Civil Engineering Contractors and with the Export Group for the Constructional Industries, and hoped before long to put before the Board of Trade a plan to meet that form of competition abroad. Furthermore, Sir Bruce pointed out that a mission had been active in the Caribbean area to investigate the possibilities of obtaining work there. He hoped that discussions which were now taking place with Government departments would result in satisfactory arrangements being made whereby British engineers and manufacturers might be able to compete in those countries on even terms. Sir Bruce also expressed the opinion that the Government's interest in the consulting engineer should take a more practical form, particularly with regard to taxation and by giving more work to consulting engineers in this country, allowing the consulting profession to develop satisfactorily with a proper trained staff, which was essential if work abroad was to be undertaken. The toast of "the guests" was proposed by Mr. J. Duvivier, who was chairman of the Association last year, and Mr. H. Robertson, president of the Royal Institute of British Architects, replied.

Water Power in the Italian Alps

No. VIII—(*Continued from page* 448, *March 27th*)

The description of the Societa Adriatica di Elettricita's works given last week is concluded here with some notes on Pieve di Cadore dam. The dam of the S.M.I.R.R.E.L. Aluminium Company on the Travignolo River is also described, the constructional plant used for these two dams, which were built by the Torno Company, being noted in more detail.

THE principal reservoir of the Piave-Boite-Vajont scheme at Pieve di Cadore is formed by an arch gravity dam of exceptional interest from the technical point of view. It is shown in Figs. 47 and 48, from which it may be seen that the deep gorge on the right bank is closed by a " plug," 57m in depth, and the arch gravity section is built above it, blocking the wider valley formed above the flat plateau of the Pian delle Ere, with a height of about 55m (the total height is thus 112m), and a crest length of 300m, corresponding to a radius of curvature of about 161m. The dam is therefore of larger radius than is customary with arch gravity structures ; it was the first arch gravity design to be constructed in Italy. For these reasons, and because of the particular site conditions, very extensive investigations and model tests were carried out to evolve the final design. The result is a structure of great economy and of very graceful appearance (Fig. 49) ; its appeal is not so dramatic as the steeper lines of the Lumiei or S. Guistina dams, but the wide radius of the curve gives the structure an elegance which blends well with the contorted peaks of the Dolomites on each side of the valley.

The problems which had to be solved in the design of the Pieve di Cadore dam were discussed in some detail in the paper mentioned last week, so that only a brief account of the layout and design is given here, followed by some details of the plant employed for the construction of the dam.

The intake of the diversion tunnel to Soverzene power station consists of twin tunnels on the left bank, which join together after passing control chambers excavated near the dam. The spillway is also on the left bank and consists of two balanced gates of shutter weir design, with a steeply sloping tunnel behind them, leading to an open channel which discharges into the stream bed well below the dam. There are two scour culverts, one at middle level and one at bottom level, which were used as diversion tunnels during construction ; during exceptional floods discharge can take place over the parapet of the dam.

The dam rests on a peripheral joint, somewhat similar to that at Lumiei, the position of which can be seen in the cross section. In 1948 the deep plug and the dam up to the level of this joint were concreted ; the next spring, when concreting was resumed, construction of the gravity arch proper was started above the joint, on concrete which had matured all the winter ; this joint and the other contraction joints were grouted on completion of the work. Contraction joints generally were formed by the concrete surfaces and no spaces were left, as the temperature rise during concreting did not exceed about 15 deg. Cent. However, to avoid any tensile stresses contraction joint surfaces were coated with bitumen. The temperature rise was kept at the low figure mentioned above by the use of ferro-pozzolanic cement having a low " *modulo calcareo* " (i.e. the ratio of calcium oxide combined with silicon dioxide to silicon dioxide), again in a manner somewhat similar to that utilised for the construction of Lumiei dam. An extensive array of measuring and recording instruments have been embodied in the dam. They are all observed from a control room in the building on the right bank, so that as time goes on a valuable record of temperatures, strains, deflections, uplift pressures, and so on, will be collected. Similarly any movement of the dam will be recorded from a system of levelling and triangulation points established for this purpose. It is hoped to gather information from these instruments which will be of use in designing future dams and will possibly allow some economy in design ; Lumiei dam has been similarly treated. Although it is now customary to install some plumb lines, thermometers, &c., in dams when they are built, the set of instruments in Pieve di Cadore dam is far more elaborate, and it is thought that a comprehensive record will be accumulated.

Constructional Plant

The accompanying plan, Fig. 47, shows the layout of the constructional plant at the site of Pieve di Cadore dam. The plateau of the Pian delle Ere, which was practically flat, provided an excellent situation for the layout of the plant, after some excavation had been carried out to bring it to a general level of 636m. The main works were started in 1947 and completed in thirty-three months.

The concreting plant was laid out to meet the specification of a production of 1000 cubic metres daily, but in fact an average substantially higher than this figure—1700 cubic metres—was maintained during the second concreting season of 1949, and a maximum of 2650 cubic metres was placed in one day. Cement was brought by rail in bulk containers to the railhead shown in the illustration, and transported by a compressed air pipeline to the silos on the Pian delle Ere. This installation was of larger size than any previous Italian one, and was capable of handling 45 tonnes of cement per hour. The cement was stored in eight large silos ; there were two 15cm diameter pipes from the railway station to the silos, a distance of 800m, with two 80 h.p. compressors ; two similar compressors handled the cement from the silos to the batching plant.

Aggregates were obtained from a quarry on the left bank. The " funnel " method of excavation was employed, the principle of which is clearly shown in the diagram—the excavated material is tipped down the shaft and discharged into trucks which take it to the crushing plant. These " funnel " quarries have been found to be convenient on several Italian dam sites, both for quarrying for aggregate and for excavation. For instance, at Lumiei dam, where a considerable volume of excavation was required in the confined space of the very steep gorge, " funnels " were built at several levels, thus substantially improving on the rate of progress possible by other methods and obviating the onerous task of recovering excavated materials from the bottom of the gorge.

The crushing and screening plant was laid out to take full advantage of the difference in level between the quarry and the concrete mixers, and consisted of three installations—primary and secondary crushers and grinding machines for the production of fine aggregates. The materials were stocked in hoppers in sizes of 0–4mm, 4–16mm, 16–40mm, 40–75mm and 75–120mm. The largest size was not used for the facing concrete on the upstream of the dam.

The aggregates were graded by volume by a method which, the contractor states, gives results quite as accurate, and far more cheaply, than by weigh batching. A belt conveyor ran under the hoppers to the concrete mixers. The aggregates were discharged on to this conveyor, the fine aggregate being discharged first so that it gave some protection to the belt when the larger sizes dropped on it. The quantity of each size of aggregate depended upon the time that the feeder at the bottom of its hopper was operated. This time was remote controlled by a rotating drum (not unlike a musical box in its mode of action) in which two pegs were fixed for each grade of material ; as the drum rotated, the pegs operated relays, the first peg starting the flow of material and the second stopping it. The proportions of the mix could be altered simply by changing the positions of the pegs.

At the lower end of each hopper there was a conventional pan, or plate feeder, adjustment of both stroke and discharge opening of which could be made. The drum rotated every ninety seconds, this being the time fixed for a batching cycle at normal frequency. Possible changes of mains frequency did not affect the operation of the feeders, as they would act both on the speed of the drum and of the feeder motors.

There were therefore three conditions regulating the quantity of aggregate to be delivered—stroke, discharge opening and number of strokes of each feeder. The original calibration of the feeders was effected by checking the weights of materials discharged. A rough adjustment was obtained by regulating the stroke and the opening, in a manner to suit the size of the aggregates, and by fixing the number of strokes per minute (thirty to fifty). The final adjustment was arrived at by altering the number of strokes to give a maximum error of ± 1 to 1·5 per cent. The high number of strokes necessary to obtain a single batch resulted in a reduction of this percentage error.

It is pointed out that percentage differences higher than the above figures might occur, whenever the grading of the individual classes of aggregates changed, and particularly when, owing to inefficient screening, the percentage of undersize existing in a class of aggregates, varied. In that case, adjustment was effected according to the data supplied by the grading diagrams, which were obtained once or twice daily for each individual class of aggregate. This inconvenience (which did not depend on the batching method and which is unavoidable in every constructional plant), however, gave rise to smaller changes in the concrete grading curve, the contractor points out, than would have been obtained by weigh batching. In effect, the first method results in an increased quantity of the smaller sizes, leaving unchanged that of the larger ones, while, with weigh batching, the quantity of the small sizes increases and of larger ones decreases ; the small increase in yield obtained in the first instance is of no consequence.

In practice, the great number of checks carried out made it possible to ascertain that the difference from the theoretical quantities in 50 per cent of cases was less than 2·5 per cent, and in 80 per cent was less than 5 per cent, and the maximum recorded value was 9 per cent. These data relate to the

situation before batching was changed following the change in the screening conditions.

There were four 2-cubic metre concrete mixers, giving a production of 120 cubic metres per hour with a mixing cycle of four minutes. Water was measured by volume, and cement by weight, there being 200kg of cement per cubic metre for the hearting concrete, and 250kg for the facing concrete. From the mixer, the concrete was discharged into bottom-dumping skips which were transported on Decauville tracks to the various cranes. The skips were also designed by the contractor with the object of preventing segregation of the concrete during transport.

As may be seen from Figs. 47 and 48, six cranes were provided for placing the concrete. At each abutment there was a derrick capable of lifting 3 tonnes with single tackle and 6 tonnes with double tackle.

The king post of each of these derricks was 30m in height, and the length of the jib 50m. The derricks were of Italian manufacture, of tubular welded steel construction, braced in a manner similar to that shown in Fig. 53. The controls of each derrick could be operated from a distance, so that the operator could be placed to view the concreting work clearly, thus avoiding indirect signals with consequent loss of time. The four tower cranes, also of Italian manufacture, travelled on 6m gauge rails round the downstream part of the dam. The inner rail rested on the dam itself, and the outer rail was carried on a concrete wall built for that purpose. Each crane had a jib 30m long, which was 52m above rail level in the horizontal position. Under these conditions the crane could lift 3 tonnes at maximum radius ; with the jib luffed to a height of 70m, 6 tonnes could be lifted. The operator's cabin was 30m above ground level, but remote control, as for the derricks, was also provided, for the same reason. A rate of operation of twenty cycles an hour was achieved with the derricks and tower cranes, and the Decauville tracks were laid out after careful study to permit a movement of 750 trains daily. The concrete was placed in lifts of 70cm, and reduced to 50cm by consolidation with immersion vibrators.

Cranes of the size used at Pieve di Cadore are something of an innovation on public works projects. The contractors, Guiseppe Torno and C.S.p.A., of Milan who also built Lumiei dam, prefer the use of such cranes to that of cableways, which, they say, amongst other things, are more expensive. We illustrate overleaf some other examples of similar plant used by this firm, Fig. 52 shows two guy derricks at the site of the Fiastrone dam of the Unione Esercizi Elettrici on the river of the same name near Rome. This dam will be an arch gravity structure 90m in height, with a volume of 160,000 cubic metres, and a reservoir capacity of 35 million cubic metres. The photograph reproduced here was taken in 1951 and a substantial volume of concrete has now been placed. The two cranes each have a jib 50m long, a king post 52m long and a capacity of 6 tonnes with a rate of operation of 20 cycles an hour. There is also a "Terry"

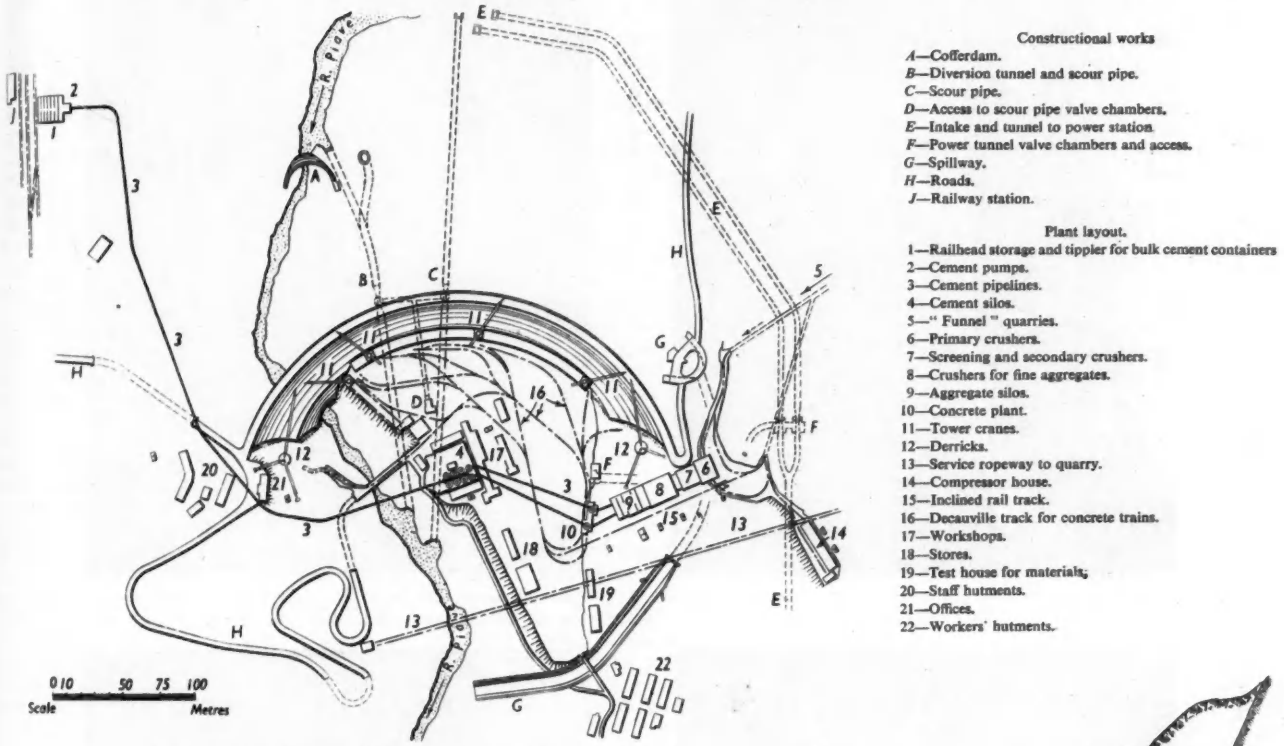


Fig. 47—Plan of Pieve di Cadore Dam and Constructional Plant

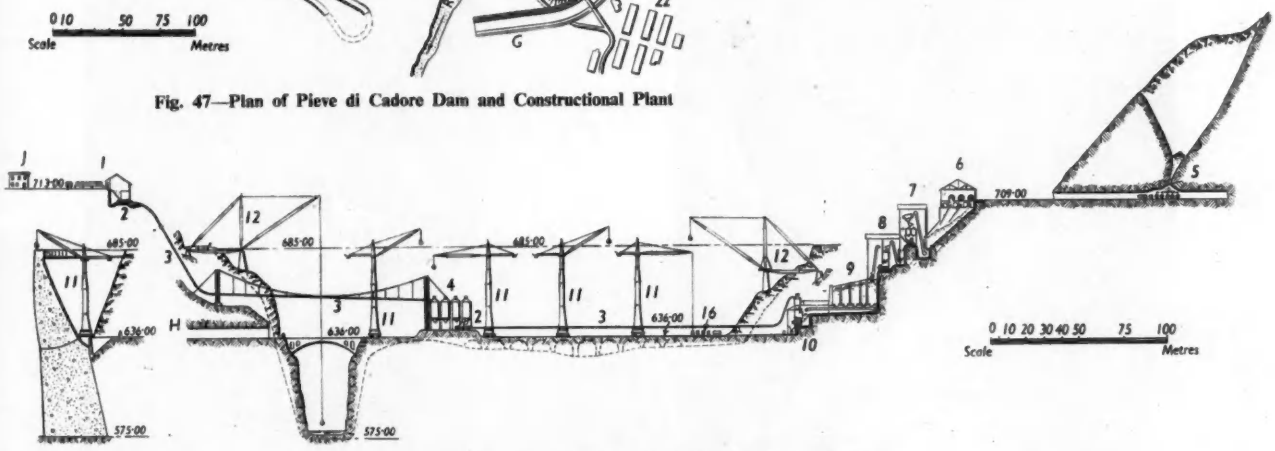


Fig. 48—Constructional Plant at Pieve di Cadore Dam

Another example is that of the Forte Buso dam on the Travignolo river. This river is a tributary of the Avisio and the dam is about 60km from Pieve di Cadore. It has been built for S.M.I.R.R.E.L., an aluminium company, and the power generated by the project will be consumed in that company's works. The dam is an arch gravity structure, 110m in height. It was shown in cross section in Fig. 46 (last week) and is illustrated in Figs. 50, 51 and 53. The dam has a volume of 265,000 cubic metres and forms a reservoir of 32 million cubic metres capacity. Water is diverted through a series of five power stations with a total head of

THE CONSTRUCTION OF THREE ITALIAN ARCH GRAVITY DAMS

Fig. 50—Forte Buso Dam

Fig. 52—Derricks at Fiastrone Dam Site

Fig. 49—Pieve di Cadore Dam

Fig. 51—Forte Buso Dam Under Construction

some 1100m and a total installed capacity of 129MVA, there being a second reservoir of 30 million cubic metres capacity at Cismon, before the last power-station of the series. The dam was first designed as a gravity buttress structure with a volume of 400,000 cubic metres, but the design was changed to the present arch gravity one with a saving of 135,000 cubic metres in volume. A peripheral joint, as with the other dams, is incorporated and the construction joints have been curved to follow the lines of principal stress. The position of the joints—both peripheral and construction—can be clearly seen on the upstream face of the dam, shown in Fig. 51, whilst Fig. 53 shows the slight stepping-in of the downstream face at the level of the peripheral joint, and also the curve of that joint up the side of the dam. The dam is markedly asymmetrical inside this joint; it has a length along the crest of about 330m and a chord length of about 250m. The principal diversion tunnel from the reservoir is 12km in length, with 17km of collecting tunnels. Again, some similarity with the design of Pieve di Cadore may be seen, both for Forte Buso and Fiastrone dams. The same tradition is also apparent in the Beauregard dam, which is described next week.

The dam is situated in a steep gorge and advantage has again been taken of the natural slope in the layout of the crushing and screening plant on the right bank. The method of measuring the aggregate described above for Pieve di Cadore dam has again been used here. Concrete is taken in 2 cubic metre skips, to be placed either by the guy derrick on the right bank or by the stiffleg derrick on the left bank. Skips are transported to the derrick on the left bank on a simple bi-cable ropeway just upstream of the dam. Another ropeway, just downstream of the dam, transports 1 cubic metre skips to a tower crane on the left bank. The latter is similar to the tower cranes at Pieve di Cadore and ran on a track built on the downstream side of the dam. The use of tubular steel and bracing wires on the derricks may be particularly noted and the "outrigger" bracing on the various main members. The stiffleg derrick is of the same general design as those employed at Pieve di Cadore, whilst the guy derrick on the right bank is similar to those shown at the Fiastrone dam site. This installation of cranes and derricks was again chosen, as it was thought to be more economical than a cableway. In the early stages of construction the stiffleg derrick was positioned just downstream of the left bank abutment, as it is shown in Figs. 51 and 53. Later on it was positioned higher up just upstream of the left bank abutment, and the tower crane was then installed on the downstream side.

Fig. 53—Construction of Lower Part of Forte Buso Dam

(To be continued)

High-Speed Counting of Steel Foundry Dust Particles

By G. M. MICHIE, M.A., A.Inst.P., A.I.M.*

A number of recent contributions to the scientific Press† have drawn attention to a novel technique‡ developed by Professor J. Z. Young of University College, London, in which a method is suggested for the quantitative assessment of microscope images. Display of the specimen is achieved by means of a "flying-spot" microscope employing television principles, which effectively converts a two-dimensional space image into a voltage/time series, susceptible to quantitative analysis. The technique is of considerable potential interest in relation to a number of fields of medical, scientific and industrial research, and in particular to problems involving the counting of microscopic particles. The assessment of airborne dust concentrations in steel foundries may be regarded as typical, since the difficulty associated with the counting of dust samples seriously restricts the extent to which the silicosis problem may be investigated by means of environmental studies. For this reason, the British Steel Founders' Association, as part of its programme of industrial health research, has, since mid-1951, been giving financial support to the further development of the "flying-spot" microscope counting technique along the lines proposed by Mr. F. Roberts and his colleagues, Mr. D. Causley and Dr. D. R. Wilkie.

The principles upon which the technique is based, and the lines upon which it is being developed are described in the following article, which is published by courtesy of Professor J. Z. Young and the British Steel Founders' Association.

THE "Flying-Spot" microscope is essentially an instrument which has been developed in an attempt to make it possible to secure quantitative information from microscopic images. Most microscopic work is primarily concerned with providing a "picture" of the object under investigation, rather than with giving quantitative measurements of any kind. In certain classes of work, however, it is measurements rather than pictures that are required, and in order to secure such information it may be necessary to subject the pictures to detailed analysis, a procedure which is often both tedious and time-consuming. Such an instance arises in the assessment of atmospheric dust samples, where it is usual to express the dust concentration in terms of the number of particles in unit volume of air. When the sample is obtained by means of an instrument such as the Owen's jet or thermal precipitator, it takes the form of a deposit on a glass cover slip, which must be examined under a high-power microscope. The particle concentration is subsequently determined by means of a visual count. In routine work, the picture of the dust sample is of little interest; it is the count figure which is of importance, and which in the ordinary way can only be obtained by painstaking work on the part of a human observer.

The problem of measuring the numbers and sizes of small particles is one which is receiving attention by research workers in many different spheres.‖ The particles of interest are for the most part too small to lend themselves to treatment by mechanical methods, and consequently the majority of techniques which have been studied involve scanning either the specimen or its magnified image by a small element arranged to move progressively over the whole of a representative field. Techniques involving scanning of the magnified image suffer from numerous drawbacks, not the least of which are associated with the lack of resolution and contrast in the image consequent upon the limitations of optical systems. The "Flying-Spot" microscope is unique in that it does not employ the optical microscope for the purpose of magnifying the specimen, but instead uses it in reverse, as a means of producing a very small spot of light which is subsequently made to scan the actual specimen. The display of the specimen at high magnification is not an essential feature

* British Steel Castings Research Association.

† "A Flying Spot Microscope," J. Z. Young and F. Roberts, *Nature*, 1951, 167 (4241), February 10th, 231; "High-Speed Counting with the Flying Spot Microscope," J. Z. Young and F. Roberts, *Nature*, 1952, 169 (4310), June 7th, 963.

‡ British Patent Application No. 11499/51, dated May 16, 1951 in the names of J. Z. Young, F. Roberts, D. Causley and D. R. Wilkie.

‖ "Automatic Counting of Microscopic Particles," *Nature*, 1952, 169 (4300), March 29th, 518–520.

of the counting technique, but it so happens that it is possible to project an image of the specimen on to a television tube screen with a resolution at least as good as that obtainable in conventional microscopy. In practice, this is, of course, very desirable, since it provides a convenient means both of focusing the scanning spot upon the specimen, and of selecting the desired field.

The approach to the counting problem will perhaps be better understood by first outlining the technique as it is used for visual display of the specimen.

Method of Producing Visual Display

The principle of the technique is schematically illustrated in Fig. 1. The source of light

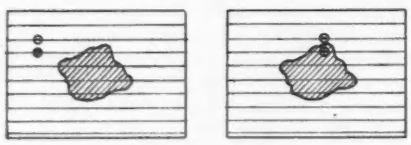


Fig. 1—Principle of Visual Display

is the screen of a small television type cathode-ray tube, the moving spot on the screen of which is about 25 microns (0·025mm.) in diameter. This tube is set up in front of the ocular of an ordinary compound microscope. The light, after passing through the ocular, is focused by means of the objective to form a minute moving spot of light which scans the specimen twenty-five times per second. The amount of light transmitted by the specimen at any given instant is determined

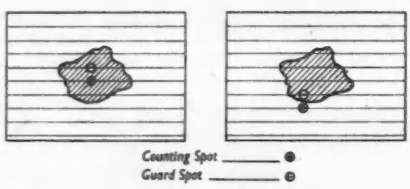


Fig. 2—Principle of Guard Spot Technique

by the density of the specimen at the particular point illuminated, and is measured by means of a sensitive photo-multiplier cell mounted behind the specimen, below the sub-stage condenser. The output from the photo-cell is amplified and used to modulate the intensity of the cathode-ray beam in a standard television display tube, the moving spot of which is arranged to scan in synchronism with the source. (In other words, the time base of each tube is provided by a common generator.) By this means the screen of the display tube reproduces the transmission pattern of the specimen, at a magnification determined by the size of the area swept by the spot on the display screen and by the optical magnification of the microscope.

Method of Particle Counting

In the simplest case we may consider the problem of counting the number of particles in a given field, when all the particles are of constant and known size. By feeding the output of the photo-cell into a standard counter chronometer, the time during a single scan in which the beam is obscured by particles, may be recorded. Since the time required for a single complete scan is known (one-twenty-fifth second), the proportion of this during which the spot is obscured may be determined. This is effectively a measure of the area occupied by the particles, and since their size is known, their number may readily be deduced.

The general and more difficult case is, however, the assessment of samples composed of particles of different shapes and sizes, and to achieve this an intercept count method has to be employed. In other words, the voltage pulses from the photo-cell which arise each time the scanning spot crosses a particle in the sample must be resolved and counted. This in itself is not unduly difficult to achieve, but it will be appreciated that as long as the diameters of any of the particles are larger than the distance between two scan lines (as in fact will normally be the case), the number of intercepts in a single scan will exceed the number of particles. In order to overcome this, a method has been devised which makes use of what is known as a "guard spot." This is a second spot of light which scans the specimen exactly one line behind the counting spot. Whereas, however, each intercept of the counting spot gives rise to a positive impulse, each intercept of the guard spot gives rise to a negative impulse, so that by arranging that only positive impulses operate the counter and that simultaneous positive and negative impulses cancel each other out, it is possible to record the first intercepts of the counting spot without recording subsequent intercepts on the same particle. This scheme is diagrammatically illustrated in Fig. 2.

The sorting and grading of these impulses is achieved by means of an anti-coincidence circuit, the design of which must take into account the fact that pulses from intercepts on adjacent lines are seldom of the same length. Furthermore, it will be appreciated that the counter must be made to operate during the scanning of one frame only. On pressing the reset button of the counter, the actual count of all the particles in the field should therefore be obtained in a period of one-twenty-fifth second.

A schematic diagram of the "Flying-Spot" microscope as it has been developed for counting purposes is presented in Fig. 4, the experimental equipment being illustrated in Fig. 3. It will be noted that the method of obtaining the guard spot makes use of a doubly refracting crystal of calcite which is placed between the scanning tube and the ocular of the microscope. This is so chosen and subsequently orientated that the two resulting

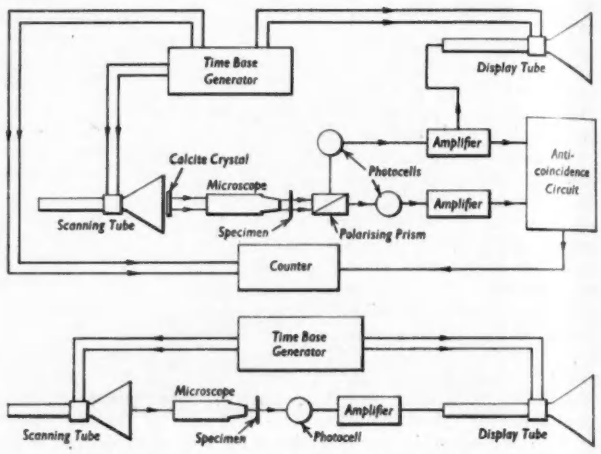


Fig. 4—Block Diagram of "Flying Spot" Microscope

spots of light which fall on the specimen are exactly one line width apart. Since they are plane polarised at 90 deg. to each other, they may, after passing through the specimen, be directed into separate photo-multiplier tubes by means of a polarising prism. The pulses from these two tubes are then passed to the anti-coincidence circuit, which ensures that the counter registers only when the counting spot alone is obscured.

Potential Applications of the "Flying-Spot" Microscope Technique

Mention has already been made of the promise held out by the "Flying-Spot" microscope technique as a means of avoiding the time-consuming counting operations usually associated with the assessment of airborne dust concentrations. Existing methods of dust counting, by setting a limit

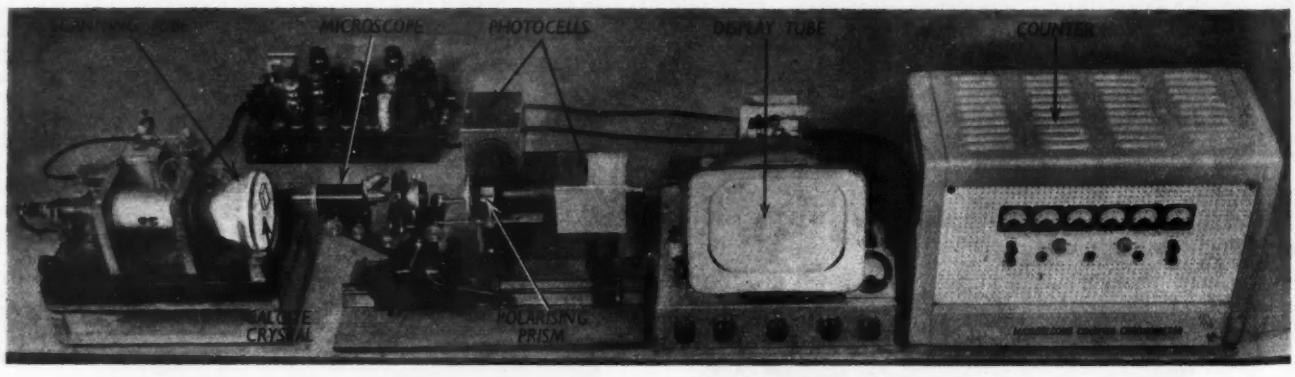


Fig. 3—Experimental Equipment of "Flying Spot" Microscope

to the number of samples which can be handled, effectively determine the scale upon which it is possible to investigate industrial conditions associated with the incidence of pneumoconiosis. The availability of rapid automatic methods of dust sampling and assessment is, in fact, considered of prime importance in determining the extent to which the silicosis problem in the steel foundry industry can be investigated by means of environmental studies.

Aside, however, from this important potential application, the technique is of considerable interest in relation to other fields of research. As far as visual projection of the specimen is concerned, for instance, some of the advantages offered by the method of display are as follows :—

(*a*) Owing to the small size of the scanning spot (0·1 to 0·25 micron, depending upon the objective employed in the microscope) and the fact that adjoining parts of the specimen are illuminated at different times, diffraction between adjacent areas does not occur as it does at high magnifications in conventional microscopy. This should permit high resolution to be obtained at magnifications beyond those normally employed with the optical microscope.

(*b*) High brilliance of the screen image may be achieved without the necessity for a high intensity illuminant. The control which the method affords over image brilliance permits microscopic examinations to be carried out using very low illuminating intensities, an important consideration in such work as the examination of grains of photographic emulsion, for instance. The direct display of infra-red or ultra-violet images is also possible, and in view of the fact that living tissue can be altered by ultra-violet radiation, the advantage of being able to examine specimens at low illuminating intensities will be apparent.

(*c*) The control available over the amplifier again permits control of the image contrast. This allows magnification of the specimen contrast by as much as 100 times, a great advantage in cases where only weak contrast is present in the specimen. This control over image contrast is, in fact, an important consideration in determining the efficiency of the counting mechanism, and has, in fact, suggested a method for discrimination between particles of different mineral constitution.

(*d*) It is not a requirement of the technique that the image should be examined at a point adjacent to the specimen, since the output of the photo-cell can readily be led to any required distance for display purposes. This could be an important factor, for instance, in the examination of radio-active materials.

All the above remarks apply with equal force when the method is extended to the problem of counting. While the technique was originally conceived with a view to providing a method for the rapid counting of the blood and brain cells, quite a large number of other potential applications have since become apparent.

By employing a metallurgical microscope, for instance, the possibility is suggested of carrying out automatically such operations as inclusion counts, grain size determinations, and the assessment of phase distributions. The control which the method affords over image contrast should permit discrimination between different types of inclusions or phases, as the case may be, much in the same way as it has been suggested that it should be possible to discriminate between different mineral particles in an airborne dust sample. As in conventional microscopy, so in "Flying Spot" microscopy, phase differentiation might be further assisted by the use of the phase contrast technique.

Present Stage of Development

As far as providing a technique for display or projection is concerned, equipment designed for this purpose will shortly be commercially available.§ The work at present being undertaken at University College is primarily concerned with the development of equipment for counting and sizing small particles. It has already proved possible to count specimens containing particles of simple geometric shape, such as are provided by photographic reductions of clusters of circles drawn on a sheet of paper. Furthermore, the size distribution of such "particles" has been obtained by the use of a pulse width discriminator which allows only intercepts of a given width to register. It can be arranged that this pulse width discriminator is reset automatically on each successive scan, so that a series of counts may be obtained from which the size distribution curve can be directly derived.

Estimation of the size distribution of particles of irregular shape is, however, more difficult and has not yet been achieved in practice. There are several approaches to the problem and these form the subject of current investigation at University College, where it is maintained that, since all the information contained in the microscope field is, in fact, translated into electrical pulses, its quantitative interpretation is mainly a matter of developing suitable pulse analysis equipment.

§ Cinema-Television, Ltd., Lower Sydenham, London, S.E.26.

Some Locomotive Dimensions Compared

By W. A. TUPLIN, D.Sc., M.I.Mech.E.

The cylinder efficiency of a steam locomotive varies but little over such a wide range of tractive effort that there is no critically good relation between major dimensions of boiler and cylinders. Some piston valves are excessively large for the normal speed range of the locomotives concerned. Consideration of fundamentals suggests a basis for rational design.

IN the past, commentators on locomotive design have been prone to work out ratios of dimensions of locomotives in the expectation of finding some correlation between the ratios and the performance. A favourite subject for examination of this sort is the relation between dimensions of the boiler and those of the cylinders, there being a vague idea that if the cylinders are too big for the boiler the engine may run itself "out of breath" and if the cylinders are small in relation to the boiler, the boiler cannot be overtaxed and the engine will be capable of almost anything.

A ratio that has been much discussed in this connection is that of heating surface to cylinder volume, rather carelessly assumed to have some relation to the ratio of potential steam production to possible steam consumption. Even the fact that this ratio has shown variations extending over a range of 3 to 1 in successful express passenger locomotives left some writers unsuspecting that it has no significance. Heating surface has a bearing on the efficiency with which heat produced at any particular rate may be conveyed to the water, but it is no measure of what the rate of heat production may be. Cylinder volume is no measure of the rate of steam consumption, first, because the boiler is not required to fill the cylinders (no locomotive works at 100 per cent cut-off); secondly, because the cylinder demand depends on the number of reciprocations of the piston per minute, and, thirdly, because the possible steam output (in cubic feet per minute) of any boiler depends on the steam pressure. Any boiler will supply any cylinders if the steam pressure, the speed or the cut-off is low enough. The range of practicable cut-off is determined by dimensions of valves and valve gear, but only in recent years has it become usual for published figures to include those dimensions.

The essential factors in the problem with which examiners of the (heating surface/cylinder volume) ratio were fumbling are :

(*a*) The potential power output of the boiler ;

(*b*) The speed range over which the cylinders are capable of using the steam efficiently, and

(*c*) The speed range over which the valves are capable of handling the steam as the cylinders can use it.

Examination of locomotive performances (see The Engineer, October 17, 1952) shows that grate area is an adequate measure of boiler power, modulated to a degree negligible for estimating purposes, by variations in ratio of firebox heating surface to grate area. Maximum power production does, however, depend to a large extent on the required duration of the effort. A sustained output of 45 i.h.p. per square foot of grate area is possible, and although scheduled running times have not usually demanded such intensity of effort, there is a case for considering it, while for shorter periods, something considerably greater is a reasonable expectation. The range from fairly easy running over a long period to a big effort for a few minutes is about 35 to 75 i.h.p. per square foot ; 45 i.h.p. per square foot is a reasonable figure for general calculation.

A diagram reproduced in The Engineer for February 10, 1950, shows that the highest cylinder efficiency is secured when the "indicated tractive effort" lies between about 0·25 and 0·35 times the nominal tractive effort, but it must be understood that there is no sudden drop in efficiency at the limits of that range. The corresponding speed range for any power output has an upper limit,

$$\frac{\text{I.H.P.} \times 375}{0{\cdot}25\ \text{N.T.E.}}, \quad \text{m.p.h.}$$

and this becomes

$$67{,}500\,\frac{G}{T}, \text{ say } 70{,}000\,\frac{G}{T}, \quad \text{m.p.h.}$$

where

G = grate area (square feet).

T = nominal tractive effort (pounds) at 85 per cent boiler pressure if i.h.p. is taken as 45 G.

The lower limit of the speed range is 0·25/0·35 times the upper limit, or 50,000 G/T.

From the same diagram it may be seen that the speed range over which valve events permit this highest efficiency to be attained

is from 0·3 to 0·6 times the "nominal speed," equal to :

$$N = 1100\frac{DVL}{d^2S} \text{ m.p.h.}$$

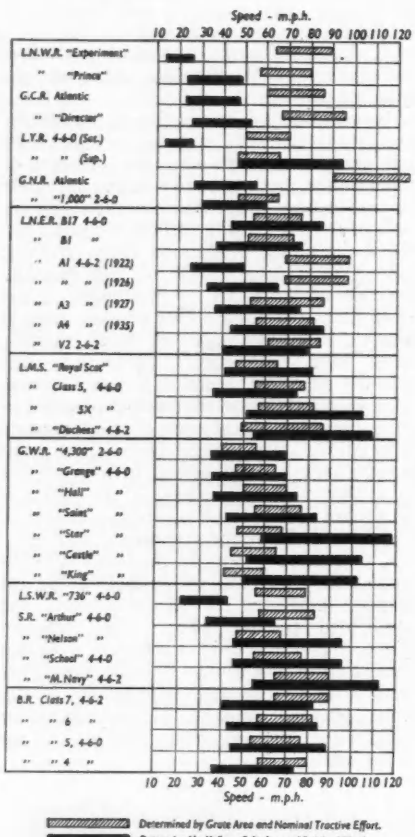
where

D=diameter of driving wheels.
V=diameter of valve.
L=lap of valve.
d=diameter of cylinder bore.
S=Stroke of piston (all in inches).

(The factor "1100" is an average value for the sonic speed in superheated steam in locomotives. For saturated steam, "1100" is replaced by "1000.")

The ratio between the upper and lower limits of this speed range is greater than for the one determined by grate area and nominal tractive effort, and it is clearly desirable that the wider range should contain the narrow one. It is interesting to examine the positions of these speed ranges for different classes of locomotive, and the diagram below enables this to be done conveniently.

It will be noticed that in many cases the two speed ranges match well, but that in others they are widely separated. An extreme example of this last condition is afforded by the G.N.R. large "Atlantic" (L.N.E.R. class "C1"). The G/T range is well above



Speed Ranges for Various Locomotives

normal running speeds and this means that it was only at such speeds that the cylinders could use the full output of the boiler efficiently. On the other hand, the 0·3–0·6 N speed range is well below normal running speeds in fast passenger service, and this means that the valves are not large enough in relation to the cylinders to permit them to produce the output otherwise possible at cut-offs below 30 per cent. These locomotives could never be highly efficient, but they could develop power greatly in excess of normal requirements at the time when they were designed. In certain extreme cases engines of this class have produced as much power per square foot of grate area as others much more suitably proportioned for such efforts, but there is no reason to doubt that the "Atlantics" used coal very extravagantly during these exploits and on test at normal outputs they burned over 5 lb of coal per drawbar horsepower-hour.

It is interesting to note how successive Doncaster designs of "Pacifics" showed improved correlation of the speed ranges. Not only do they approach symmetrical setting in the "A4 Pacific," but the narrower range, 58 to 82 m.p.h., is clearly appropriate for a high-speed locomotive. It must be added that the full capacity of Gresley "Pacifics" was demanded by very few schedules (the "Coronation's" 71·9 m.p.h. average King's Cross–York with about 325 tons gross was perhaps the only one), and so the relative displacement of the speed ranges of the 1926 "A1s" was not seriously detrimental. The 1850 i.h.p. corresponding to the 70 to 98 m.p.h. range could be replaced by about 1400 i.h.p. for normal purposes, and for this the G/T range is 53 to 74 m.p.h., overlapping the valve capacity range. It may be added that the essential difference between the 1922 and 1926 versions of the Gresley "A1" was a change in valve lap from 1¼in to 1⅛in. It is interesting to note that whilst the Gresley "Pacifics" did not attain ideal correlation of speed ranges till 1935, Gresley's three-cylinder, 2–6–0 (later L.N.E.R. class "K3") had achieved some overlap in 1920 with a speed range (47 to 60 m.p.h.) that is a good compromise between the requirements of passenger traffic and "fitted freight" trains.

It should be emphasised again that there is no catastrophic drop in efficiency as the speed passes out of any range for maximum efficiency, and so absence of overlap in the two ranges for any given locomotive is not fatal. Nevertheless, it is desirable in designing a locomotive to make the 50,000–70,000 G/T range and the 0·3–0·6 N range overlap the operating range over which maximum power is required.

It may be remarked that the G.W.R. two-cylinder designs showed ideal proportioning as far back as 1903, but that the four-cylinder designs incline to be "over-valved." This implies a tendency to unnecessarily low cylinder efficiency at low speeds (because excessively free exhaust causes cylinder pressure to vanish while it could still be useful), and this agrees with the impression formed by some observers, that the four-cylinder engines are not so well suited to heavy "slogging" at low speeds as are the two-cylinder designs. The fact that the former have Walschaerts valve gear and the latter Stephenson gear is an obvious difference between the two groups and has sometimes been mentioned as a possible reason for the (not certainly established) difference in operating characteristics, but the differences in valve events when pulling hard are extremely small and seem unlikely to have any perceptible effect on performance.

The Southern Region examples show good correlation of speed ranges, and the later replacement of the "Lord Nelson's" 8in valves by 10in valves would seem to be a step in the wrong direction.

In general, British designs since the late 1920s are well proportioned in this respect for express passenger service, but many pre-grouping designs had undesirably low nominal speeds and most slide valve engines are defective in this way.

Such comparisons as these are interesting, but at the most they can be significant only when made between accurately built, well-maintained locomotives in good condition. An incorrect setting of the blast pipe, a dirty boiler or leakages of steam may have far greater effect on power and efficiency than any departure from ideal proportioning of major dimensions.

Any insistence that in designing a locomotive the cylinder diameter must be right to the last quarter-inch, or the act of reducing cylinder diameter by ½in with the expressed aim of improving the steaming, suggests imperfect acquaintance with the broad principle, easily discernible in the diagram, that cylinder diameter, even with every other dimension fixed, is not critical.

Many locomotives in the past have had to be worked at late cut-off because the valves were too small to give adequate port openings at early cut-off. It is not usually difficult in the design stages to provide appropriate valves, and most modern locomotives are satisfactory in this respect. It does not suffice, however, merely to put in very large valves with the comment that they are "ample." It is possible for valve dimensions to be more than ample and rational design takes into account the range of speed over which the locomotive is required to develop its full power efficiently.

B.S.R.A Resistance Experiments on the "Lucy Ashton"*

By J. F. C. CONN, D.Sc.,† H. LACKENBY, M.Sc.,‡ and W. P. WALKER§

No. II—(*Continued from page 469, March 27th*)

In this paper the results of the resistance trials in the "Lucy Ashton" are analysed to establish ship model correlation for the rated hull conditions. Test conditions and the work carried out to establish the roughness effect of several surface conditions are described, together with the wind tunnel tests. The resistance of the "Lucy Ashton" models are extrapolated on the basis of the Schoenherr, Telfer and Prandtl-Schlichting lines and the Froude method, and the predictions compared with the actual results.

Section B.—The Measurement and Analysis of Hull Surface Roughness

Treatment of Bottom.—When the vessel was docked it was found that, after scraping and cleaning, the steel bottom was pitted and rough to the touch. Because of the importance of surface roughness on skin frictional resistance the bottom was carefully treated to make it comparable with that of the freshly painted plates of a new steel ship.

Two thin layers of rivet cement were applied at an interval of several days in order to allow the layers to dry out thoroughly. Two coats of commercial red oxide paint were then applied as the basic surface. This treatment produced a good surface which was comparable with that of a freshly painted new ship. On immersion the surface lost its glossy appearance, but roughness measurements showed that the resulting matt surface was as smooth as the original.

It became known that bituminous aluminium paint would probably give a smoother surface than the ordinary red oxide paint, and this was confirmed by roughness measurements made on sample plates, so it was decided to carry out additional trials with the hull treated with this paint. This aluminium paint, which was applied directly to the original red oxide surface, differs from the red oxide in that the aluminium suspension is lamellar rather than granular and, on drying out, the small metallic flakes align themselves parallel to the surface and interlock to form what is in effect a thin layer of aluminium foil. When applied in cold damp weather it did not adhere very well and patches were sometimes found where the top coat had "exfoliated." The exfoliated patches were very smooth to the touch when flattened out by hand, and it was con-

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§William Denny and Bros., Ltd.

sidered that they have negligible effect on the resistance.

With regard to the arrangement of the plating, there were three longitudinal overlapped seams per side below the water line, as shown in Fig. 4. The plates were ¼in thick and the edges were sharpened to make them comparable with similar seams on a new ship. The butts of the plates were flush on the outside. The rivet heads had been worn almost flush in the course of the ship's long service, and they were covered by the applications of rivet cement.

For fairing the seams, rivet cement was used in the first instance. This filling material had very poor adhesive qualities, and during the tests much of the fairing material fell off. To use a latex-base composition Semtex was proposed, but it had a comparatively rough surface, which completely counteracted the beneficial effects of the seam fairing. This fairing, which formed an appreciable percentage of the wetted area of the vessel, was given a thin skin of rivet cement to produce the same smoothness of surface as on the rest of the hull, and in this condition the tests with aluminium paint were repeated. The fairing consisted of bands of composition 3in wide with a straight taper from ¼in to zero thickness, thus giving a surface slope of 1 in 12.

After each trial the ship was docked and the hull surface lightly rubbed down with pumice and a single coat of fresh paint was applied. When a new paint surface was to be tried two coats were applied in the first instance.

The Measurement of Hull Surface Roughness.—Due to the importance of surface roughness on skin frictional resistance, measurements of the state of the hull surface were made throughout the trials, and sample painted plates were submitted to laboratory examination. Whenever possible, two roughness records were taken at each of ten stations on both sides of the ship before and after each trial.

Three types of instrument were used. The wall gauge, made available by the Metrology Division of the National Physical Laboratory, consists of an exploring probe tipped with a ¼in diameter steel ball, which is caused to traverse the surface over approximately 12in. The movements of the probe normal to the surface are recorded on a stationary strip of paper by means of a stylus giving a vertical magnification of 10. This instrument is useful for recording local unfairness in the plating or long-period "waviness." The aerofoil gauge, also made available by the Metrology Division, N.P.L., was designed for the examination of the surface finish of aerofoils. The gauge slides along a flexible metal apron which rests on the surface and the probe, which has a point of $\frac{1}{16}$in diameter and projects through a slot in the apron, has its vertical movement magnified eighteen times and transmitted to a stylus, which makes a record to a contracted-base scale on a smoked glass plate. The travel of the gauge is 6in, but it is capable of recording surface roughness with undulations of wavelengths as low as $\frac{1}{16}$in and of detecting the grosser differences in the quality of paint surfaces. The Talysurf machine, which is not portable and must be used in a laboratory, is capable of detecting differences in roughness height of as little as one-millionth of an inch, so that the minute differences between the textures of different paints become measurable. The exploring probe has a tip radius of 0·0001in and its movement is amplified electronically and recorded with a high degree of magnification by a pen recorder.

The Nature of Hull Roughness.—It is usual to regard rivet points and plate landings as roughness (structural roughness) when considering the frictional resistance of ships, but in the following remarks the term roughness is restricted to the small irregularities that occur on the otherwise fair surfaces of hull plating. The profile of such a surface consists of a series of humps and hollows, the contours of which consist of superposed undulations. A more sensitive roughness gauge shows that these lesser irregularities are not in themselves smooth. From a visual examination of records it is possible to compare them qualitatively; but the analysis of the records in such a way that a quantitative comparison becomes possible is difficult, particularly when it is desired to find a roughness parameter that can be correlated with the hydrodynamic properties of the surface.

In the absence of a satisfactory roughness parameter it was decided that the analysis of the roughness records from the "Lucy Ashton" should be directed towards the determination of coefficients which would define the profiles as completely as possible, so that any roughness parameter that might be adopted in the future could be evaluated.

Analysis of the Roughness Records.—It was realised that the method of analysis should be simple and that it would not be possible to introduce all the variables involved, but as the essential factors appeared to be the amplitude and frequency it was considered sufficient to take account of these.

A method for determining the mean height of roughness from recorded profiles consists in drawing enveloping curves through the highest peaks and deepest hollows respectively. However, it is possible to obtain widely differing results when identical records are submitted to this form of analysis, since much depends on the judgment of the operator. Therefore when the roughness height is quoted the corresponding mean frequency of the roughness should also be given.

The roughness heights corresponding to each of a given series of frequencies (or undulations per inch) have been determined as follows. A tracing paper grid of equi-spaced vertical lines was placed over the record and smooth curves were drawn connecting respectively the highest peak and deepest hollow that occurred in each section. The mean separation of these curves is designated the mean apparent amplitude of the roughness for the frequency corresponding to the spacing of the lines of the grid. The process was repeated using a series of grids in which the spacing of the lines was successively halved; thus the mean apparent amplitudes were obtained corresponding to a set of frequencies forming a geometrical progression of common ratio two.

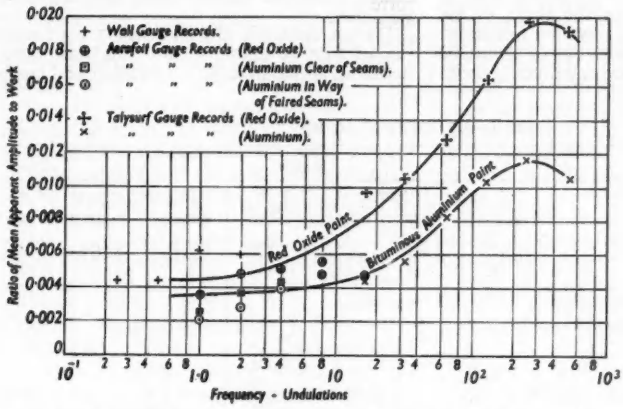

Wall Gauge Records.
Aerofoil Gauge Records (Red Oxide).
" " " (Aluminium Clear of Seams).
" " " (Aluminium In Way of Faired Seams).
Talysurf Gauge Records (Red Oxide).
" " " (Aluminium).
Red Oxide Paint
Bituminous Aluminium Paint
Ratio of Mean Apparent Amplitude to Wave
Frequency - Undulations

Fig. 3—Plotting of the Ratio of Mean Apparent Amplitude to Corresponding Wavelength on a Base of Frequency in Undulations Per Inch, with Curves Showing General Trends for Red Oxide and Bituminous Aluminium Paint

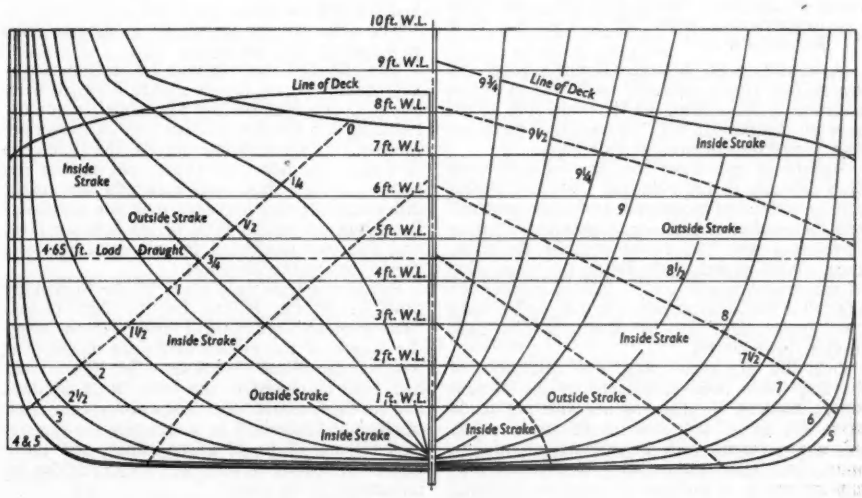


Fig. 4—Body Plan

NOMENCLATURE AND SYMBOLS

A = Cross-sectional area of water in experiment tank.
A_m = Midship section area.
A_T = Transverse projected area of the ship above the waterline.
A_w = Area of waterplane.
a = Mean cross-sectional area of model = $\frac{\nabla}{L}$.
B = Maximum breadth to mean thickness of shell.
b = Breadth of water surface in experiment tank.
C = Resistance coefficient = $\frac{R}{\frac{1}{2}\rho V^2 S}$.
C_f = Frictional resistance coefficient = $\frac{R_f}{\frac{1}{2}\rho V^2 S}$.
C_b = Block coefficient = $\frac{\nabla}{LBd}$.
C_m = Midship area coefficient = $\frac{A_m}{Bd}$.
C_p = Prismatic coefficient = $\frac{\nabla}{A_m L}$.
C_w = Waterplane area coefficient = $\frac{A_w}{LB}$.
d = Mean moulded draught to top of sagged keel.
e.h.p. = Effective horsepower.
g = Acceleration due to gravity.
k = Wind resistance coefficient = $\frac{R}{\frac{1}{2}\rho V_r^2 A_T}$.
k_s = Equivalent sand grain size.
L = Length of ship (*LBP*).
R = Resistance in general.
R = Frictional resistance.
R_r = Residuary resistance.
R_t = Total resistance.
R_n = Reynolds number = $\frac{VL}{\nu}$.
S = Wetted surface area.
$t°$ = Temperature of water.
V = Speed.
V_r = Relative wind speed.
v = Tank carriage speed.
Δ = Displacement.
∇ = Volume of displacement.
δh = Depression of water level in way of model due to backflow.
δv = Backflow velocity in way of model due to constriction.
ν = Coefficient of kinematic viscosity.
ρ = Specific density.
ϕ = Ratio of frictional resistance to total resistance = $\frac{R_f}{R_t}$.
© = R. E. Froude's resistance constant
$= \frac{125S}{\pi \nabla^{\frac{2}{3}}} C = \frac{2938R}{\Delta^{\frac{2}{3}} V^3} = 427 \cdot 1 \frac{\text{e.h.p.}}{\Delta^{\frac{2}{3}} V^3}$,
where R and Δ are in tons (salt water) and V is in knots
AP = After perpendicular.
FP = Forward perpendicular.
ABP = Amidships between perpendiculars.

As regards the performance of the three different instruments, where the frequency ranges overlap there is reasonably close agreement between the results. The aluminium paint surface is generally smoother than the red oxide, and this is shown in Fig. 3. At low frequencies of about one per inch the difference is very small, but this increases with increasing frequency, and between 16 and 256 per inch the amplitude or roughness height for the aluminium paint surface is only about 60 per cent of that for the red oxide surface.

Another interesting point is that the ratio of amplitude to wavelength or the slope of the undulations increases with increasing frequency, reaching a maximum at a frequency of about 300 per inch. At this position the amplitude is about 1/50 of the wavelength for the red oxide paint and about 1/80 for the aluminium paint. The ratio never approaches the value of one-half which would be associated with uniform sand grain roughness and apparently, geometrically, the nature of clean-paint ship roughness differs appreciably from sand roughness.

TABLE I—*Particulars of Models*

	Models						Ship
Length on load waterline, ft	9	12	16	20	24	30	190·5
Model scale	1/21·17	1/15·88	1/11·91	1/9·525	1/7·938	1/6·35	1
Breadth, extreme, ft	0·9949	1·327	1·769	2·211	2·653	3·317	21·06
Draught moulded, ft :							
At perpendiculars	0·2197	0·2928	0·3904	0·4882	0·5858	0·7323	4·65
At midships	0·2363	0·3225	0·4300	0·5375	0·6450	0·8063	5·12
Volume of displacement, cubic feet	1·442	3·414	8·093	15·80	27·31	53·35	13,650
Wetted surface, square feet :							
Including rudder and stern post, excluding bar keel	9·720	17·28	30·72	48·01	69·12	108·0	4,355
Including rudder, stern post, and bar keel	—	—	—	—	—	—	4,488
Midship area coefficient, C_m				0·972			
Block coefficient, C_b				0·685			
Prismatic coefficient, C_p				0·705			
Waterplane area coefficient, C_w				0·785			
½ angle of entrance of waterline, $\frac{1}{2}\alpha_e$				12¼ deg.			
LCB from amidships *BP*, per cent *L*				1·956*A*			

Note.—In calculating the coefficients of fineness a mean moulded draft of 5ft corresponding to the level-keel condition has been taken

TABLE II—*Offsets of Ship and Models*

Stations (spaced 19·05ft apart)	0	½	1	1½	2	3	4	5	6	7	8	8½	9	9½	10
Moulded waterlines, ft	Waterline offsets per cent full ½ breadth (10·53ft)														
0	0·7	1·5	6·4	19·4	43·3	81·1	88·8	88·8	83·9	63·9	29·1	16·1	4·3	—	—
0·5	0·7	5·2	18·6	39·6	62·5	88·3	93·8	93·8	90·8	74·7	46·2	29·2	13·2	—	—
1	0·7	8·9	27·1	50·5	71·6	92·5	96·7	96·7	94·1	80·8	54·5	37·0	19·4	4·5	—
2	0·7	16·7	41·8	65·6	83·1	97·2	99·3	99·3	97·8	88·0	64·4	47·3	28·8	11·5	—
3	0·7	24·9	54·2	75·8	89·3	98·7	100·0	100·0	99·5	91·1	70·6	54·2	35·5	16·1	—
4	0·7	33·8	64·4	82·4	92·0	98·7	100·0	100·0	100·0	93·0	74·6	59·2	40·5	19·6	—
5	0·7	43·8	72·6	86·6	93·6	98·7	100·0	100·0	100·0	94·1	77·4	63·0	44·6	22·6	0·7
6	0·7	55·2	78·8	89·3	94·5	98·7	100·0	100·0	100·0	95·2	79·9	66·2	48·0	24·9	0·7
7	0·7	67·1	83·4	91·3	95·3	98·7	100·0	100·0	100·0	95·8	81·9	68·9	50·7	27·1	0·7
8	30·6	76·9	87·1	92·6	95·7	98·7	100·0	100·0	100·0	96·3	83·6	71·2	53·0	28·8	0·7
9	67·9	83·3	90·1	93·8	96·0	98·7	100·0	100·0	100·0	96·8	85·3	73·2	55·2	30·6	0·7
10	73·1	86·6	92·5	94·8	96·3	98·7	100·0	100·0	100·0	97·2	87·0	75·1	57·5	32·3	0·7
Knuckle ½ breadth, per cent ½*B*	67·4	82·1													
Knuckle height above base line, ft	8·92	8·67													
Sag of keel, in	0	0·66	1·24	1·94	2·74	4·22	5·29	5·61	5·28	4·44	3·48	2·82	2·04	1·20	0

Note.—The offsets were lifted from the ship and correspond to mean thickness of shell

Section C.—The Model Results and their Correlation with the Full-Scale Ship Resistance

As stated in Sir Maurice Denny's paper the aim of the "Lucy Ashton" trials was to obtain accurate measurements of full-scale ship resistance for comparison with the resistance predicted from model tests in an experiment tank.

Resistance tests have been carried out in the Ship Division of the National Physical Laboratory on a series of models of the "Lucy Ashton," and the results are presented, together with their correlation with the measured full-scale resistance. With regard to the latter, the translation of the model results to the full scale has been effected in the usual manner using R. E. Froude's "0" values, and also by several modern skin friction formulations.

Only the four clean naked hull conditions of the ship have been considered in the present report, namely, (i) sharp seams with red oxide paint, (ii) faired seams with red oxide paint, (iii) sharp seams with bituminous aluminium paint, (iv) faired seams with bituminous aluminium paint. Condition (i) may be regarded as the normal clean service condition of the ship; condition (iv) was the smoothest condition of the hull surface which it was practicable to obtain.

The Model Tests.—Resistance tests at the corresponding ship draught and displacement were carried out on a series of six geometrically similar models of the "Lucy Ashton" of lengths 9ft, 12ft, 16ft, 20ft, 24ft and 30ft. The geometrical particulars for the ship form are shown in Table I. The offsets to which the models were made are shown in Table II, and correspond to the mean thickness of shell. The body sections are shown in Fig. 4. The form had no parallel middle body and the maximum section was at midships.

During the trials, the ship had a permanent sag of 5¼in at midships, and this was reproduced on all the models. The rudder and stern-post were reproduced on the models and were the only appendages fitted.

The models were made in wax, and the resistance was measured over a range of speed to cover the corresponding ship range of 5 to 15 knots. The tests were first made without trip wires and were then with standard trip wires of 0·036in diameter fitted at 5 per cent of the length abaft the stem.

The observations are shown in tabular form in Appendix II of the paper.

The effect of the trip wire on resistance was very small. At the lowest speeds, it varied from about 2 per cent on the 9ft model, gradually reducing to a fraction of 1 per cent on the longer models. At intermediate speeds, the difference was generally less than 1 per cent and at the highest speeds there was generally no visible difference. It was apparent that this particular form was subject to little or no laminar flow, and this was confirmed by ink detection tests carried out on the 9ft model.

Roughness tests were made by the Metrology Division of the N.P.L. on the 20ft model. Measurements were made at three positions along the length of the model, and were repeated at roughly the same positions after the model had been immersed in the water for four days and six days respectively. The average amplitude of roughness obtained by integrating the records varied from 12 to 17 micro-inches, and there was no indication of increased roughness due to immersion in the water.

(*To be continued*)

Hydraulic Lifts in Tractors

At a general meeting of the Institution of British Agricultural Engineers, which was held in London on Tuesday, March 24th, a paper dealing with hydraulic lifts in modern tractors was presented by Mr. H. E. Ashfield. Mr. Ashfield said that the use of power lifts in tractors originated in this country about twenty years ago, and that now the hydraulic transmission of power seemed to have superseded other forms—pneumatic, mechanical and electrical.

Mr. Ashfield went on to explain that there were two means of using hydraulic power. The first, on smaller tractors, consisted of lifting the implements bodily, the latter being attached to the tractor by a three point linkage. In this case the actuating mechanism was internally built into the tractor and was one-directional only, the weight of the implement acting as the return force. The second form of power actuation, used on larger tractors, consisted of a remote cylinder which could be fitted on to the implement or auxiliary equipment in use and thus enable it to be actuated from the driver's seat. The advantages of that were obvious as, if necessary, a number of hydraulic tappings on the tractor system could be used selectively to actuate a number of controls on the equipment. Mr. Ashfield said that either a two-way or one-way power cylinder could be employed depending on the system in use. On inbuilt lifts where a gravity return was used, the hydraulic pump was usually driven from behind the clutch, which had, of course, the disadvantage that when the clutch was depressed the system was inoperative.

After discussing control valves, Mr. Ashfield made some reference to the pumps used in a tractor hydraulic system. In the main, he said, gear pumps or multi-cylinder reciprocating pumps were now employed. He went on to say that tractor hydraulic systems should operate at pressures between 1000 lb and 2000 lb per square inch. This did not mean necessarily that they normally worked at these pressures, but that the highest pressure prior to blowing the relief valve or ceasing to function should be of that order. The advantages of the high pressure system from a functional point of view were that as only a small amount of oil was needed to do the actual work, the action of the lift in either direction was smooth and fast, being relatively unaffected by changes in viscosity.

The paper explained that this was very apparent in, say, the operation of a tip trailer or front mounted loader when, if a large ram was used with low pressure oil, the return stroke when the bucket or trailer was empty would take some time to force oil out of the ram. The higher the pressure within the system, the smaller and more compact it could be for a given amount of work required. On the other hand, with high pressure a very high degree of accuracy was necessary in the manufacture of the components as errors which were acceptable in the low pressure system would render the high pressure system ineffective. Much more elaborate sealing arrangements were necessary on the pipe joints and valve facings.

Mr. Ashfield thought, therefore, that the choice was between a low pressure system, simple to manufacture but using big quantities of oil to do a given amount of work, and a small, compact system using a small amount of oil but every part being precision made and using high-grade material.

In some general conclusions, Mr. Ashfield suggested that if the power lift was to be supplied as auxiliary equipment, two kinds of external lift could be designed, one being virtually an in-built lift but contained in a separate housing and bolted on at the rear of the tractor, the three point linkage system being attached to this housing or to the axle adjacent to the housing. Such a lift was quite effective on a small tractor of, say, under 30 h.p. Alternatively, for larger tractors and in some cases the small ones, the built-on lift could be wholly external, comprising front mounted pump, external pipes, oil reservoir, control valve and remote rams. By positioning the rams at various points on the tractor, rear mounted, front mounted or mid-mounted attachments could be operated, the rams being either one-way or two-way.

The Institution of Naval Architects

ANNUAL SPRING MEETING

No. I

THE annual spring meeting of the Institution of Naval Architects opened on Wednesday, March 25th, in the "Wellington," the headquarters ship of the Honourable Company of Master Mariners, Victoria Embankment, London, and was presided over by Viscount Runciman of Doxford.

In the annual report of the Council for 1952, it was recorded that Viscount Runciman of Doxford, the president, had been elected an honorary member of the Society of Naval Architects and Marine Engineers, and an honorary member of the Associazione di Tecnica Navale. Mr. J. L. Adam, C.B.E., and Dr. S. F. Dorey, C.B.E., F.R.S., have been elected honorary vice-presidents by the council, and it was recorded that General D.-Ing. Giuseppe Rota has been made an honorary member of the Institution. The membership continued its steady rate of increase and the treasurer advised that a small increase in subscription rates would be necessary next year.

Two Premiums for 1952 were awarded, namely, to Mr. W. H. Dickie, for his paper "High-Powered Single-Screw Cargo Liners," and to Mr. A. J. Williams, R.C.N.C., for his paper, "An Investigation into the Motions of Ships at Sea." In connection with the Samuel Baxter Prize for 1952, two awards were made—to Captain J. Logan, for his paper, "Some Observations on Towing Tensions, Towlines and Problems Connected with Open Water Towing," published in the *Journal of the Honourable Company of Master Mariners*, and to Mr. J. W. Gillie, for his invention of a "Unit Trim Indicator." Mr. W. B. Wilson, of Birkenhead Technical College, was awarded the Duke of Northumberland Prize.

Notes upon the work of the Tonnage Measurement Laws Committee were included in the report, together with a statement that the Institution and three other founder Institutions had withdrawn from membership of the Engineering Joint Council, formed by them in 1922. The councils of the Institution of Naval Architects and the Institute of Marine Engineers, it was stated, have authorised the formation of a new Southern Branch. The report included brief notes relating to research work carried out, during 1952, by organisations in which the Institution is interested, namely, the Ship Division, National Physical Laboratory; the British Shipbuilding Research Association; Pametrada and the British Welding Research Association. The results of the 1952 scholarship examinations were given and also a list of the scholarships offered for competition in 1953.

Viscount Runciman of Doxford then gave his presidential address, abstracts from which are printed below.

We cannot allow this occasion to pass without recording our pleasure that Her Majesty the Queen has graciously continued the Royal Patronage which the Institution has enjoyed since the days of King Edward VII. That is an event which must give us all the very greatest satisfaction.

Another much more recent event is that within the last few days Viscount Weir of Eastwood has generously presented to this Institution a sum of £10,000, free of all conditions. That is the sort of benefaction which it is not our good fortune to receive very often, and I am sure that in addition to those letters which have already been forwarded to Lord Weir this meeting would like to express its appreciation of his generosity. I can only say that it adds to our pleasure that we know he has extended similar generosity to other bodies comparable with ourselves in the sort of general field of activity which we cover. So that he really has come out as a patron of these arts and sciences in no small way.

Your council and house committee will consider what use to make of this generous gift, and if any member has any ideas perhaps he will communicate them to the secretary.

You have already heard from the treasurer that a special meeting to deal with the new by-laws and regulations is to be called for May 13th. It will be of great advantage to us to get these by-laws and regulations tied up, and I hope there will be a reasonably acquiescent gathering on that occasion.

Reference has been made by the treasurer and the secretary to the printing of the *Transactions*. It is most important that we should not lower the very high standard of printing of these *Transactions*, which go all over the world. You have heard of some of the ways in which we have tried to meet the cost without reducing the quality, and in view of the very heavy cost of printing, I suggest that those who contribute to the discussions should do their best to make their contributions as concise as possible.

We had a very successful meeting last autumn in Italy. Arising from that, we are indebted to our vice-president, Mr. E. L. Champness, for having provided a gavel which we have sent to the Associazione di Tecnica Navale as a momento of that occasion.

This year it has been arranged to hold an autumn meeting in Holland on September 14th to 19th.

Reference is made in the report to the joint branches of this Institution and the Institute of Marine Engineers, and no doubt this meeting would like to record its pleasure and satisfaction in the progress which has been made. Since there are many more marine engineers than there are naval architects, membership of their Institute will always be larger than that of our Institution, and that raises certain problems where joint branches are concerned, but as the past has shown, those problems are by no means insoluble, and I look forward to many years of fruitful collaboration between our two bodies in their joint branches.

On the further future events this year, I think you are aware that the "Normannia" has been chartered to enable members to see the Naval Review. The council has considered whether it would be practicable to remain in the Review area late enough to see the illuminations, and we were forced to the conclusion that it would not be practicable. Therefore it has been decided that the ship will leave the Review area during the earlier period in which it is open to navigation, about 6 o'clock in the evening, which will enable the party to get back to London at a reasonable hour.

You are also aware that the Institution has been allotted a number of seats in Parliament Square and in Hyde Park on the occasion of the Coronation. The applications greatly exceeded the number of seats available, so a ballot was held, and those successful in securing seats have been informed.

Another matter to which I would refer is the membership of this Institution. It is a remarkable fact that since the end of the war our membership has increased by more than 1000. I am sure you will agree that that has been achieved without any lowering of the quality of our membership, and we may regard it as a very welcome accession of strength and a most encouraging sign. Not only are we doing a good job as an Institution, but we have so persuaded people that we are doing so as to make them wish to join us.

A slightly disagreeable matter which has been touched on by the treasurer is the necessity to raise our subscription. The increase proposed is by no means large, and the meeting might like to know that even with the proposed increase the subscription will be only double what it was ninety years ago.

Those are some of the points which have stood out during the past year and which are likely to engage our attention in the future. I think we may feel pleased as an Institution with the work which has been accomplished and resolve to do even better in the future.

The first paper presented at the meeting was "B.S.R.A. Resistance Experiments on the 'Lucy Ashton': Part II, The Ship Model Correlation for the Naked Hull Conditions," by J. F. C. Conn, D.Sc., H. Lackenby, M.Sc., and W. P. Walker. An abstract of the paper appeared in our issue of March 27th and is continued on page 488 of this issue. This paper is complementary to a paper read by Sir Maurice Denny before the International Conference of Naval Architects and Marine Engineers, 1951, giving the results of the "Lucy Ashton" trials carried out by the British Shipbuilding Research Association under its director, Dr. S. L. Smith. An abstract of the paper appeared in THE ENGINEER of July 6, 1951.

DISCUSSION

Mr. V. G. Shepheard: This paper marks an epoch in our *Transactions* on the subject of ship model correlation which was opened by Froude's experiments on the "Greyhound" eighty years ago, and has taken us a considerable stride forward.

The "Lucy Ashton" tests have been carried through in the full light of the developments in theory and experience since the pioneer investigation of Froude, and the conclusion reached is noteworthy in that Froude's law of comparison has been vindicated as regards wave-making resistance and, subject to the roughness allowance, as regards skin friction. The assumption that skin friction resistance can be assessed from the equivalent plank is, to quote the authors, "not strictly correct."

It is instructive to compare the authors' conclusions with those derived from the "Greyhound." Froude claimed that:

"The comparison therefore between the 'Greyhound' ship and the 'Greyhound' model certainly throws no doubt on, if it does not conclusively verify, the law of comparison between ships and models, the discrepancy which it presents being only such as might arise in comparing the performances of any given ship under two different conditions of skin."

Froude's reference to the importance of the condition of hull surface was prescient and the authors have confirmed the sensitivity of the resistance of a ship to exposed plate edges and smoothness of paint. Shortly after the trials Froude arranged for two sets of model experiments. One disposed of the suggestion that the mutual reaction of the towing ship "Active" had any sensible

influence on the true resistance of the towed ship " Greyhound." The other was to test the importance of the surmise that the resistance of " Greyhound " had been augmented by the shallowness of the water. The test proved this was indeed so and to an appreciable extent. Neither of these uncertainties arose in the " Lucy Ashton " test.

A third point is that bilge keels were removed for most of the trials on " Greyhound " to compare with the condition of the model. No record can be found of the constructional details of the keels, but it appears to have been the practice for the bilge keels of sheathed ships to be made of wood and for the sole piece adjacent to the hull to be of greater thickness than that of the hull sheathing. It is probable that when the keels were removed there remained a small projection and this may have resulted in some increase of resistance.

The information on the roughness measurements of the hull of " Lucy Ashton " is very complete and the correlation with the resistance measurements is one of the most useful aspects of the paper. It would be helpful if the authors could give information as to the standard of smoothness for ships generally and the scope for improvement. Presumably, if it were practicable for the hull surface to be refined, the skin friction would be appropriate to the smooth turbulent line and an appreciable reduction in hull resistance would result.

" Greyhound " was launched in 1859 and " Lucy Ashton " nearly thirty years later. Both are ships of an old type and are short. Although " Lucy Ashton " was tested at a relatively high speed, many ships are longer and faster, and I commend the suggestion that the work be followed up to extend the range of size and speed for which a firm comparison can be made.

Dr. J. F. Allan : These detailed results for the " Lucy Ashton," ship and models, form a valuable contribution to the study of the resistance scale effect problem and provide evidence on the associated effects of hull roughness. The seventh International Conference covering these subjects will take place next year, and important decisions will be taken. It is desirable that as much data as possible is published before then, and against that background the presentation of the results in this paper is very timely. It is particularly important to publish the data in detail, for many will wish to plot the answers in their own way and come to their own conclusions.

The authors have given details of the whole story and we are thus placed in a position to judge the interpretation for ourselves. It is pertinent to note that this work gives a few spots on the diagrams rather than a complete picture, a fact which is acknowledged by the authors when they point out that further similar work is required on larger and fuller forms. Some comparable work is in progress in Holland and the United States, and it will be interesting to see whether all the results fit into a common pattern.

The general order of accuracy of the observations is of significance. Much of the work was done at the N.P.L. and particular care was taken to obtain consistent measurements. It is considered that these model results are correct within $\pm 0{\cdot}5$ per cent, and would the authors give some indication of the standard of accuracy which they would attach to the ship measurements ?

In the course of the model experiments the effect of tank boundary interference became evident and a particular study has been devoted to that subject as a result of its being brought into prominence. In general, the authors are disposed to put their money on the Schoenherr line, and I think they make a very consistent case in relation to the interpretation of that line.

It is interesting to have confirmation of the accuracy of the Froude prediction in the important part of the speed range, but the case is very much open to argument.

Mr. R. W. L. Gawn : The broad upshot of this paper is a vindication of the methods which, more than eighty years ago, revolutionised naval architecture and have since played a dominant part in contributing to the propulsive efficiency of all classes of ship. Both the pioneer and his son steadfastly followed a policy of consistency in all their work, pending information which would make the upshot more clear. The paper shows that models can be too small or too large, and that there is still much to be learned concerning skin friction resistance.

The table indicating the percentage excess of the ship resistance over the predictions from the models at various speeds shows that predictions from model hull resistance tests and Froude's frictional coefficients agree closely with the measured ship resistance for the smoothest hull surface tested at the high speeds for this ship, above 11 knots. A previous speaker has mentioned that the authors are putting their money on Schoenherr in this paper. I propose to be more careful with my money, and point out that if we apply the standard roughness coefficient of $0{\cdot}0004$ to the Schoenherr frictional line, then the predictions are 3 per cent greater than Froude's.

One interesting point is that the reliability of the prediction seems to vary with speeds. From the speed trial analysis of warships the resistance you would deduce is less than that of the ship by an amount greater than the 5 per cent error, but broadly that amount is constant over the speed range. It varies equally with Froude and Schoenherr, and there seems to be a better tie-up in that particular respect with the Telfer prediction. There is a problem here, and it emphasises the authors' plea for further information on larger ships. The ships I have referred to are longer and faster than " Lucy Ashton." For example, the speed of 14 knots for " Lucy Ashton " becomes on Reynolds' number similarity less than 5 knots for a 600ft ship. Similarly, the low speed of 5 knots for " Lucy Ashton " is only about $1\frac{1}{2}$ knots for the longer ship.

The excess of the model predictions at low speed tempts me to mention two points. First, the wind resistance of the ship is more pronounced at slow speeds and ranges from 10 to 20 per cent of the measured resistance. The wind resistance coefficient of the ship as obtained from wind tunnel tests is about $1{\cdot}26$ in a head wind, but that is about 50 per cent greater than in most cases and greater than any to which I can find reference. There is no doubt that the experiments were done correctly, but the authors should think about the matter, for if the wind resistance has been exaggerated the deduced water resistance will be correspondingly increased and a closer overall relation with model predictions will be obtained.

The other matter is that the trip wires have increased the model resistance by as much as 2 per cent in some conditions. Since the investigation has proved that they are not necessary, it would appear appropriate to delete their effect from the correlation, and to this extent the difference between prediction and measurement would be reduced.

It is hoped that the contribution of form effect to skin friction resistance will be followed up ; but it cannot be represented by a constant percentage addition, for it will vary with wave making and with speed.

Professor Kenneth S. M. Davidson (U.S.A.) : Not since William Froude's time have we had so authoritative and complete a report on the relation between ship and model resistances. The outstanding fact is that in the interval since Froude's time we have been unable to make a significant improvement on his basic assumptions. This is not for want of trying ; it is simply because the assumptions are obviously good to a first order of approximation and because the achieving of a second order of approximation has turned out to be very troublesome.

In trying to achieve a second order of approximation, one of the most baffling problems has been to get reproducible experiments from which to start. Progress has been made in this direction through recognition of the importance of avoiding partial laminar flow, and so the choice of the " Lucy Ashton " for the present experiments seems to have been a peculiarly happy one. Apparently the tests can be accepted with little question as to turbulence. We find that (with a minor reservation) all the models tested can be aligned in accordance with Froude's assumptions on various consistent functions of the Reynolds number to within something like 1 per cent over the entire speed range. This is a significant result and one that can only be construed as evidence in support of both the Froude assumptions and the Reynolds number concept for dealing with skin friction.

It would be idle for me at this late date to try to disclaim a partiality for the Schoenherr line, but I have yet to see any other line that has stood up so well. I am impressed by the fact that in the extrapolation diagram on the Schoenherr basis the consistent alignment of the various models is also consistent with the Schoenherr line for planks. This is again supporting evidence for the Froude assumptions, because there are now two forms involved, the " Lucy Ashton " form and the generalised plank form represented by the Schoenherr line ; both are found to conform simultaneously with the assumptions.

It is important to distinguish between the two Froude assumptions. The first is that skin friction and wave making are additive components of the total resistance, and the second, that the friction of the ship is equal to the friction of the " equivalent " plank. If the second is questioned, while allowing the first to stand, it is easy to produce " modified " Schoenherr diagrams of the kind given in the paper. But the model tests alone are simply not good enough to permit a clear decision to be drawn upon the relative merits of the extrapolation diagram on the Schoenherr basis and the modified extrapolation diagram on that basis given in the paper.

I object to the statement regarding the modified Schoenherr expansion that " there is little doubt that the real model friction is at that level " (8 per cent above Schoenherr), because I do not think there is good enough evidence behind it. I suggest that the impulse for introducing the modified Schoenherr expansion was the vanishingly small roughness intercepts for the full-scale ship at the lowest speeds. The modified expansion increases those intercepts. But it does not produce a uniform intercept over the whole speed range, nor does it alter materially the trend of the variation of the intercept with speed.

At the opposite end of the range, the slightly higher resistance of the two smallest models at very low speeds tends to support the idea that the Schoenherr line may be low in the region of small Reynolds numbers.

We are re-examining the accumulated evidence on hand at the Experimental Towing Tank, and hope to make a statement about it at the American Towing Tank Conference meeting in May. The fact that the smallest "Lucy Ashton" models at their lowest speeds fall a little high with respect to the Schoenherr line is only one instance, and I note that the authors attach little weight to it.

We are moving towards a satisfactory resolution of the friction and expansion problems, but we cannot expect an ultimate resolution of these problems until model testing has been brought to a point where consistency among geosim model tests can be expected to within considerably better than 1 per cent.

Professor E. V. Telfer : As my name has been mentioned in the paper I rise at once to my own defence. I propose to examine this particular data and to demonstrate that the Schoenherr line is clearly and unmistakably wrong.

It is amazing to me how the authors can see a perfectly consistent set of spots for the low-speed model and deliberately throw them away because they do not fit their ideas that the Schoenherr line is correct. The authors should have taken any of the charts without making any hypothesis at all and should have drawn their curves through the spots, never mind whether or not they are straight. If they have drawn a set of curves through the spots they would have found that all were remarkably constant.

I have made some progress towards dealing with the tank boundary effect correctly, and I hope to show in an early paper how the whole of these results drop into line with the correct tank boundary allowance.

Mr. John Brown : In bringing the full-scale measure of resistance to a common basis for plotting, the biggest single correction is for the wind resistance factor, which reaches the large proportion of the total resistance, at low speeds, of between 10 and 20 per cent. The coefficients used in relating the wind resistance to speed have been determined from model experiments and approximately checked by full-scale work, in both cases with the wind moving across the surface and involving a boundary layer, in which the speed is less than that of the free air surrounding the main part of the model. The main hull of the model is within the boundary layer and is subjected to the lower mean speed, and so has a lower resistance than in free air. If the coefficients obtained are used to estimate the full-scale wind resistance then that resistance is underestimated. It has the consequential effect that the roughness allowance must be reduced at the lower speed. My suggestion would indicate that the roughness allowance varies with speed even more rapidly than the authors' graph shows.

Dr. G. Hughes : Our knowledge of this problem has been advanced by this paper. It must be admitted, however, that the results of the six models could not by themselves be used to predict the ship result with any certainty, and we are obliged to rely upon an extrapolation based on frictional measurements on plane surfaces.

The authors have shown the results of various methods of extrapolation. I do not think they have noticed the real trend of the model data because they have adopted the extremely dangerous procedure of arranging for linearity of plot to suit preconceived methods of correlation. By its adoption in the paper the authors have deduced an erroneous compliance with the Schoenherr correlation, and they have done less than justice to the Telfer method.

I would like to show a method of analysis based on the new friction work at the N.P.L.

In the paper which I read before this Institution a year ago I gave preliminary results which showed that in the model range the friction line for plane surfaces in two-dimensional flow (i.e. with no edge effect) is lower and steeper than the Schoenherr line. It was indicated that the effect of increasing the length/breadth ratio of the planes was to increase the frictional coefficient in an approximately constant ratio independently of Reynolds number, and that this might lead to a very simple application to model results for the treatment of form resistance. Since then the model range has been fully explored and the results agree generally with the earlier indications, but suggest that the basic two-dimensional friction line is a little lower and steeper than previously shown. Final lines have not yet been drawn, but I have applied the results to a number of model hull results at below wave-making speeds. These results cover a range of block coefficient from 0·35 to 0·81 and a range of half angle of entrance from 0 deg. to 52 deg. In all these cases the model resistance curve at below wave-making speeds agrees remarkably well with the basic friction line for plane surfaces when raised by a constant percentage, which is a measure of the "form" resistance, using the term "form" to embrace any excess above the resistance for the same length and surface area in two-dimensional flow. Thus, it appears that form effect in model hulls and length/breadth ratio effect in plane surfaces behave similarly so far as dependence on Reynolds number is concerned. In the cases examined, this percentage varies from 13 to 38 per cent, and the model curves are not therefore parallel to each other.

This correlation between model and plane results at below wave-making speeds makes the assumption reasonable that the continuation of the raised friction line will give the friction and form resistance at all speeds, and that the excess of the total resistance above this line will be the wave-making resistance.

Mr. A. Silverleaf : I suggest an examination of the results proves that highly accurate ship resistance measurements have not been, and possibly cannot be, made in normal open water conditions. Two essential quantities have undoubtedly been measured with a precision as high as that quoted in the data sheets—speed over the ground and the total resistance—but the corrections necessary to convert these two fundamental measurements into speed through the water and net water resistance are not of the same order of accuracy.

The speed measurement corrections contain two doubtful points. First, it is stated that speed calculations have been based on times for the second half mile. Yet in fifty-five runs, almost half the total, the speed on the second half mile was actually lower than over the first half. Further, the speeds over the two halves of the course differ on occasion by as much as 3 per cent either way, and these appreciable variations occur often at the higher speeds. Surely this must markedly influence the resistance coefficients.

Secondly, tidal effect corrections have been made by taking the mean of two second half-mile runs and so involve measurements in two directions over different stretches of water. Is this not contrary to accepted good practice, especially where tidal currents, although small, are confused ?

The corrections for the measured total resistance can be divided into two groups. The first comprises corrections for displacement and temperature—which are either directly calculable or deduced from reliable empirical data not likely to be subject to significant error.

The second group of resistance corrections relates to sea and weather conditions. Here is an almost unavoidable element of approximation and it is not surprising that no use has been made of the ship natural wind resistance tests. A wind strong enough to give an appreciable pull was also strong enough to set up an appreciable movement of the ship which affected the load-measuring capsule reading. The wind tunnel model results are more reliable but it is a pity, in view of the large wind and air corrections, that the assumption of no scale effect had to be based on such slender evidence. Although the sea conditions were recorded, no attempt has been made to correct for any surface ripples or waves.

Because of these doubtful correction factors I suggest that the mean corrected ship resistance coefficients are unlikely to be within less than 2 per cent of the truth.

Captain J. Logan : Comparing the "Lucy Ashton" with the "Yudachi," which was used by Hiraga for full-scale resistance tests up to 27 knots by the towing method, the dimensions of the two are not dissimilar, but when their full-scale resistance curves are compared the differences are striking. The "Lucy Ashton," although 42ft shorter, had about 6 per cent greater displacement and about 7 per cent less wetted surface. At low speeds—the speeds where skin friction comes in—"Yudachi" showed some 15 to 20 per cent greater resistance, but at top speed (15 knots) her resistance was about 30 per cent less than that of "Lucy Ashton."

From the measured resistances recorded in the trial data sheets it is noted that these are tabulated to an accuracy of ± 1 lb. This precision is impressive because, with 10in gauges calibrated to 4000 lb, the circumferential scale, without magnification, is something like 1 lb=0·008in.

In the corrected data, the high order of precision in the resistance column, to $\frac{1}{4}$ per cent at low speeds and to one-fiftieth of 1 per cent at the top speeds, is no less remarkable, because total corrections of between 5 and 12 or 13 per cent have been applied to the measured thrusts. At top speeds the total correction in some cases exceeds 1000 lb.

The records show that the average steady helm angle for the eighty runs at 12 knots and under is 2·4 deg., and I should have thought that the correction would have been appreciably more than the authors suggest.

Professor L. C. Burrill : No comment has been made during the discussion on the wave-making of this ship and the models, and I would draw attention to the fact that all the models show an appreciable hump at about 11 knots, whereas that is not present in the ship results.

I am discouraged to find that at 8 or 9 knots the comparison with the Froude procedure normally followed gave such impossible results. I am quite sure that prior to these results the tank people would have been quite prepared to test the models at 8 or 9 knots and to have told us the results would be accurate.

It has been said that the authors are putting their money on the Schoenherr extrapolator, but I think the situation in this country is that we have got our shirt on the Froude extrapolator.

I would like to utter a word of caution to those who are exponents of the Schoenherr line when they talk about accuracy. Maybe they are persuaded, by the fact that they have a figure of 0·0004, that it is accurate ; but that is about as blunt and inaccurate as a wooden spade !

(*To be continued*)

Institution of Mechanical Engineers

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1952

LAST Friday, March 27th, at the annual general meeting, the Council of the Institution of Mechanical Engineers presented the report on the work and progress of the Institution during 1952.

Membership

The numbers on the register during 1952 are shown in the following tabulated statement :—

Membership of Institution of Mechanical Engineers

	Hon. M.	M.	A.M.	C.	Assoc.	G.	S.	Totals	
Totals at December 31, 1951 ...	34	4,761	15,086	32	956	12,082	4,698		37,649
Elected	2	43	311	2	18	1,517	1,033		
Reinstated	—	—	5	—	1	4	3		
Transferred	—	106	917	—	4	793	—		
Total additions during 1952	2	149	1,233	2	23	2,314	1,036	4,759	
Deceased	5	143	110	—	4	11	6		
Resigned	—	8	23	—	24	54	119		
Erased	—	10	37	—	14	38	89		
Elections voided	—	—	—	1	1	8	38		
Transferred	—	—	106	—	13	891	810		
Lapsed	—	—	—	—	—	57	218		
Total deductions during 1952 ...	5	161	276	1	56	1,059	1,280	2,838	
Net alterations during 1952	−3	−12	+957	+1	−33	+1,255	−244		+1,921
Totals at December 31, 1952... ...	31	4,749	16,043	33	923	13,337	4,454		39,570

Royal Patronage

Her Majesty Queen Elizabeth the Second has most graciously consented to become the Patron of the Institution.

Purchase of Freehold

It will be of considerable satisfaction to members to learn that during the year negotiations with the Church Commissioners for the purchase of the remaining portion of the site on which the Institution stands were brought to a successful conclusion. The cost of £73,284 12s. was drawn from the funds held by the Leaseholds Amortisation and Rebuilding Fund.

Revision of By-laws

Steady progress has been made during the year in the revision of the by-laws. Each existing by-law has been separately examined, and the Council have decided that a clearer presentation of their proposals would result if they were placed before the corporate members as a complete set of revised by-laws rather than as a collection of amendments. By the end of the year, with the assistance of legal advice, such a set of by-laws had been drafted for further examination before being submitted to the corporate members for their consideration.

By the time this annual report reaches members it is hoped that the Council will be almost ready to lay amended by-laws in draft form before corporate members for preliminary consideration.

Centennial of Engineering of the American Society of Civil Engineers

The United States Centennial of Engineering was held in Chicago from September 3 to 13, 1952, to commemorate the hundredth anniversary of the foundation of the American Society of Civil Engineers, the oldest national engineering society in the United States. Our own Institution was represented by the president, Sir David Pye, C.B., M.A., Sc.D., F.R.S., M.I.Mech.E., and the secretary, Mr. Brian G. Robbins, M.Sc. (Eng.), M.I.Mech.E. The Institution of Civil Engineers and the Institution of Electrical Engineers were represented by their respective presidents and secretaries. The party also visited New York and established valuable contacts with the presidents and secretaries of related bodies in the United States, inspecting also the headquarters of the American Societies of Civil, of Mechanical, and of Electrical Engineers in that city.

During the convention in Chicago, the delegation attended the many technical sessions of the conference, and the three presidents were invited to be the principal speakers at the important functions of their respective kindred bodies. A short visit was also made to Detroit.

Before returning from the United States, the delegation visited Canada as guests of the Engineering Institute of Canada. By special arrangements in advance, meetings were held *en route* whereby the presidents and secretaries of the three Institutions were able to meet in Windsor, Sarnia, London, Woodstock, Hamilton, Toronto, Ottawa, Montreal and Quebec, members of their respective Institutions resident in Canada.

The cordial and hospitable reception accorded to the British delegation both in the United States and in Canada was a tribute to the very friendly relations existing between the Engineering Institutions and their members, and there can be no doubt as to the value of the tour.

Specialist Groups

The Specialist Groups enjoyed another successful year of meetings, the discussions on the various papers presented being fully up to the standard of previous years. The Industrial Administration and Engineering Production Group had four meetings, the Hydraulics Group four meetings, the Applied Mechanics and Internal Combustion Engine Groups three meetings each, the Steam Group two, and the Education Group one meeting. In one of these meetings the Internal Combustion Engine and Steam Group were in collaboration ; in others the Industrial Administration and Engineering Production Group was in collaboration with the Applied Mechanics Group, and the Education Group collaborated with the Hydraulics Group. In addition, in one instance the Internal Combustion Engine Group collaborated with the Automobile Division.

The interests concerned in the different branches of mechanical engineering thus each received a share of open discussion.

James Clayton Fund

The bequest under the will of the late Mr. James Clayton provides for the annual award of a prize, a lecture or lectures, and of fellowships bearing his name. The following particulars relate to the administration of the fund during the year.

Award of the 1951 *James Clayton Prize.*—The will provides that a sum not less than one-quarter of the annual income shall be awarded as a prize to a member, associate member, graduate or student who, in the opinion of the Council, has contributed most in the year to modern mechanical engineering science by way of research, invention or experimental work ; or by a treatise or paper on a modern mechanical engineering subject ; or by originality in design ; or by service to mechanical engineering.

The sum allocated for award by the Council for the purpose during 1951 amounted to £1550, and the Council decided that the prize be awarded to Dr. H. Roxbee Cox, B.Sc. (Eng.), M.I.Mech.E., for his contribution to the development of engineering science and practice by way of invention, design and research, communicated in part in lectures during 1951.

The prize was presented to Dr. Roxbee Cox at a general meeting on February 15, 1952, and was accompanied by a certificate bearing the Seal of the Institution.

James Clayton Lectures.—James Clayton Lectures were delivered by Professor R. T. Knapp and Mr. Charles A. Chayne, both of the United States.

Awards Under the James Clayton Bequest Fund.—In June, 1952, nine new fellowships, four new grants and one extension of an existing fellowship were awarded under the terms of the James Clayton Bequest Fund. One award was not taken up owing to ill-health of the person concerned. The amount of the awards in total was over £5200.

Award of Free Places at the School of Gas Turbine Technology

Two free places at the School of Gas Turbine Technology, Farnborough, which were made available to members of the Institution by Power-Jets (Research and Development), Ltd., were awarded to the following candidates after interview :—I. D. Gardiner, B.Sc. (Eng.), G.I.Mech.E., and I. G. Strang, G.I.Mech.E.

Local Branches, Centres and Graduates' Sections

During the latter part of the year a new branch of the Institution, called the Eastern Branch, was formed to cover an area north of the Thames not at present in the territory of a branch ; a further area was also added to the Southern Branch so that the whole of England, Scotland and Wales is included within a branch of the Institution, except the London Telecommunications Region, which is easily accessible to members for headquarters' meetings. As soon as a full session for the Eastern Branch is planned it is hoped to arrange meetings in the principal towns covered by the area of the new branch.

Previously the only activities of the Institution in the area now covered by the Eastern Branch were the Luton A.D. Centre and its Graduates' Section. The A.D. Centre Committee had given a great deal of mature thought to the lack of opportunity for members in the surrounding districts to participate in the corporate life of the Institution by holding meetings for the discussion of papers of local interest, and the committee therefore arranged for an approach on the matter to be made to the Council. Following the consideration of the suggestions put forward, the initial steps were put in hand for the successful formation of the Eastern Branch, and it is appropriate to record the appreciation of the Council to the Luton A.D. Centre Committee for their help and assistance in the culmination of a proposal which the Council are confident will prove of benefit to the Institution and, in particular, to the members in the new branch.

Joint Oversea Groups

The Council is collaborating with the Councils of the Institution of Civil Engineers and the Institution of Electrical Engineers to provide facilities for members in certain territories overseas of the three Institutions to meet together for the purposes of holding meetings at which papers of mutual engineering interest are presented and discussed, to arrange visits to works, and so on.

Abadan Joint Oversea Group.—In view of the changed conditions in Abadan, the group activities have been in abeyance.

Argentine Joint Oversea Group.—Another interesting session was held in 1952, when several joint meetings were arranged.

Hong Kong Joint Oversea Group.—This new group was formed during the latter part of the year, and it is hoped that members will enjoy a series of meetings and other joint functions during 1953.

Library and Reading Room

The number of books lent to members has again increased, the total reaching 13,699. In addition, 1021 searches have been made for particular data, more members having taken advantage of the library service. The stock has benefited during the year by the addition of 2244 works, many of which have been presented, bringing the total to some 51,000 publications. The increasing cost of technical books has necessitated even more discrimination in their

selection, but the special requirements of members of the Institution are always kept in mind. Details of the works added have continued to be printed each month in the *Journal*.

In a constant endeavour to provide a first-class service and to facilitate members' access to the library, a number of case labels have been erected, together with a plan by which inquirers are readily directed to subjects in which they are interested.

The collection of periodicals, current issues of which are exhibited in the reading room, is continually being expanded, and a number of German journals have been included during the year. Many of the periodicals so exhibited are subsequently bound for permanent preservation in the library and some 450 such volumes have been bound during the twelve months covered by this report and are now filed on the library shelves. In addition, it has been found necessary to rebind nearly 100 works which had deteriorated through use.

The lighting pendants in the reading room have been replaced by modern fittings which, whilst providing more efficient lighting, have not in any way spoilt the beauty of this Georgian room.

It was felt that some economy should be effected in the production of the Brief Index of papers published in the *Proceedings*, and it was accordingly decided, in connection with the 1952 revision by the librarian, to delete references to those papers appearing from 1847 to 1936. The new index therefore covers all papers published from 1937 to 1951, and it will now be necessary to retain the previous issue of the index, i.e. 1847–1950, for references to earlier papers.

Inventions and Research

Pipe Flanges Research Committee.—Material for the third report is being collated. It is intended that this report, embodying test data, will be issued accompanied by a paper dealing comprehensively with the basic factors underlying the design of pipe flanges. This paper is in course of preparation.

Birmingham University: Investigation on Hydraulic Lock.—The main oil circuit of the remodelled experimental apparatus has been completed and the construction of the load measuring and pressure selector unit is well advanced. The first piston and cylinder, which are being produced by an outside firm, have been completed up to the stage of grinding and lapping.

A theoretical investigation has been made of its pressure distribution in the clearance between piston and cylinder and a calculation of the pressure distribution for a specified taper and clearance rate has been completed.

The theoretical work will be extended as soon as experimental verification of these results has been obtained.

King's College, London.—The small-scale differential analyser has been fairly extensively tested and the accuracy and general performance found to be satisfactory. Owing to the small size, the setting up of the machine is tedious and it is doubtful whether the use of such a machine is economically sound. The machine has been used for teaching purposes, however, and it is believed to have considerable value for that purpose. Further units are under construction and when these are completed it is expected that a number of engineering problems will be investigated.

Leeds University.—The work on helical torsion springs has been completed and an account is being published by the Institution in the form of a paper.

The production of scatter band *S–N* curves for both plain and shot-peened silico-manganese spring plates at mean stresses of 30, 35 and 40 tons per square inch has been completed on plates subjected to normal "scragging" during manufacture and the results show possibilities of considerable saving in weight with appreciable increase in life. It has, however, been found that to take advantage of this possibility it will be necessary for the plates to be scragged to very considerably greater deflections than are covered by normal specifications. The effect of increased scragging deflections is at present under investigation.

Manchester College of Technology.—The work on cutting tools is proceeding satisfactorily, and details of the investigations are as follows:—

(1) An investigation of the properties of materials when subjected to high rates of strain in shear, and the correlation of the data with current cutting tool theory.

(2) An investigation of the life of high-speed steel tools under discontinuous cutting conditions. (This investigation links, it is hoped, with the previous investigation on tool wear.)

(3) The research on tapping, which is continuing.

In addition, investigations are proceeding on methods of measuring tool deflections under load, the chatter of machine tools and machine tool vibrations in general.

Royal Anthropological Institute.—Work has continued during 1952. As the result of a grant-in-aid received from the Council for British Archæology the committee have decided to concentrate upon the origin and history of the first metals used in the British Isles. The work undertaken is the examination and analysis of Britain's earliest copper tools and weapons. When sufficient data have been collected, research upon the known deposits of copper and other ores will be undertaken to trace the sources of the various metals.

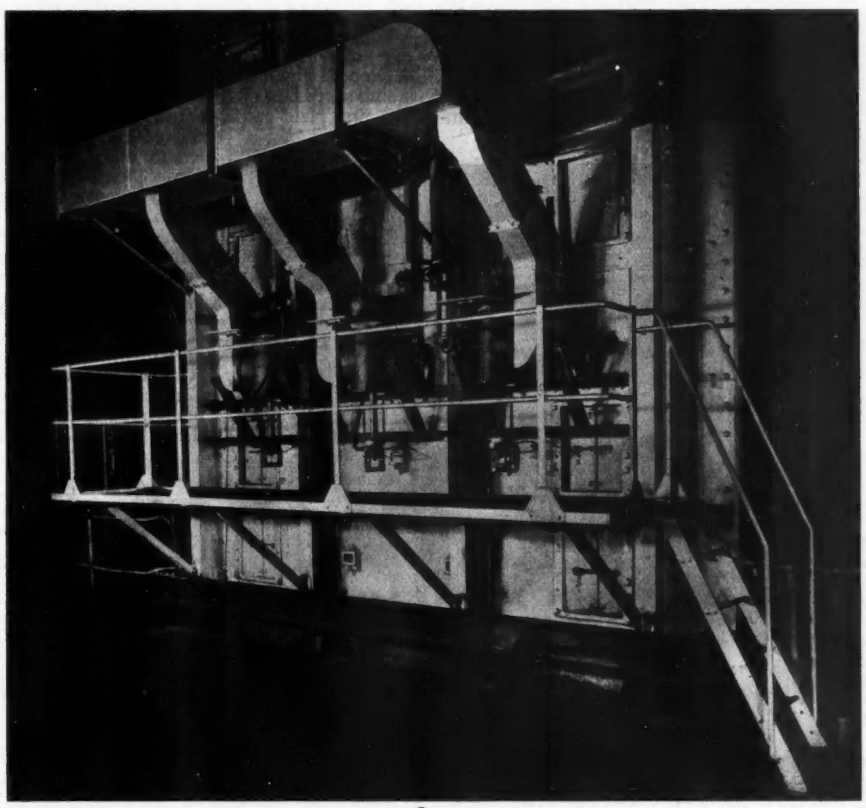
Benevolent Fund

The Council draw attention to the work of the Benevolent Fund and do so with the confident hope that members will continue their generous support of this worthy cause. Members who are not already subscribers to the fund are asked to join and in that way help the committee of management in the work they undertake for the Fund. During 1952 a sum amounting to £7586 was granted to seventy-nine cases. As the Institution bears the cost of administering the Fund, practically the whole of each subscription received is applied to the allowances and grants. In connection with the latter the committee of management have been able to assist with the education of the children of deceased members.

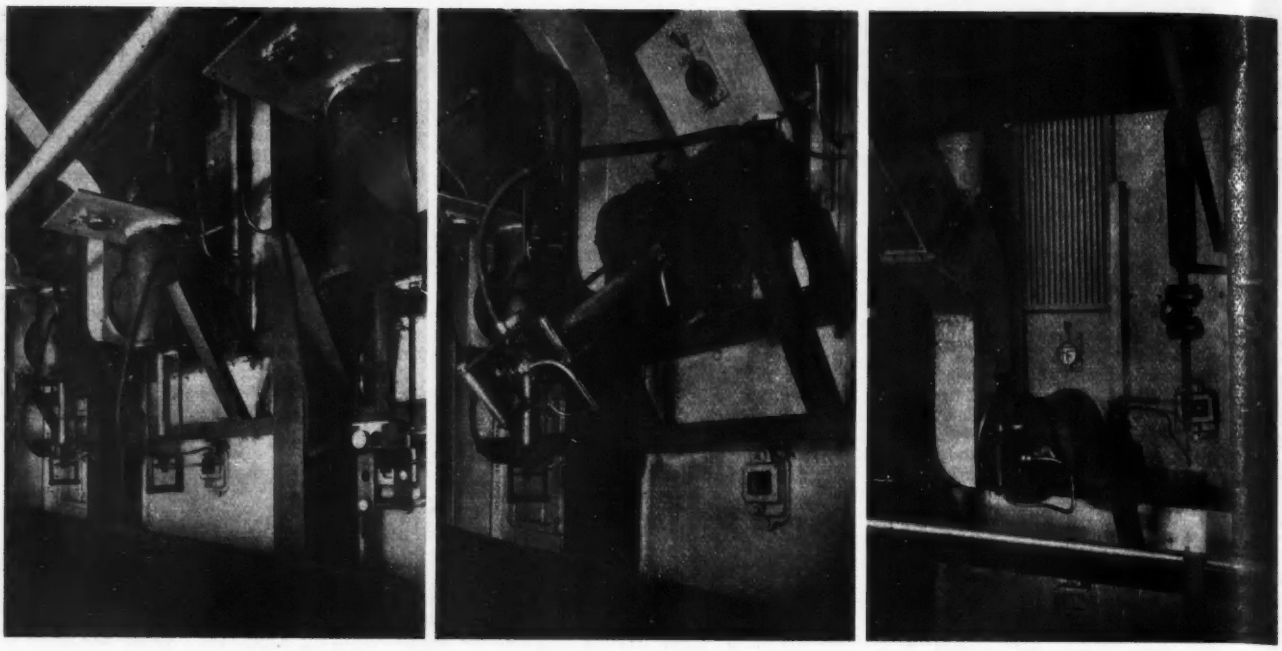
Combined Firing at St. Pancras Power Station

Oil firing equipment has been fitted to the four pulverised fuel fired boilers at St. Pancras power station to boost the steam output at peak load periods and to improve combustion. To protect the burners when they are not in use they are made retractable. A brief description of the oil burning equipment and the experience obtained with it is given here.

SINCE the war operating conditions at St. Pancras power station (London Division, British Electricity Authority) have favoured the installation of oil burning equipment for combined firing with pulverised fuel, as a means of increasing steam output to meet peak loads. For the heat release at this station was limited not so much by the capacity of the steam turbine plant as by the need to restrict smoke and grit emission. The effect of this restriction was accentuated by a number of factors. First, it was necessary to burn coal of poorer quality than that for which the station was designed. Secondly, the existing installation, one of the earlier pulverised-fuel-fired plants in the country, was becoming time expired. Three boilers used the bin and feeder method of firing and one boiler used the unit system. There was no provision for supplying preheated air for the milling of the coal. The resultant high moisture content in the fuel increased the difficulties of starting up, especially after the week-end shutdown. All these factors combined to produce inefficient combustion and tended to increase smoke and grit emission. To curb this nuisance the boiler heat release had to be limited to a



Three Oil Burner "Initiators" Fitted to No. 7 Boiler



Initiators Fully Retracted (Left) Entering the Furnace (Centre) and in Operating Position (Right)

value corresponding to a station output of 24MW, although the installed alternator capacity was 44MW.

With the aim of removing this restriction consideration was given to a scheme involving the installation of oil burners on the boilers. By using combined firing it was proposed to attain higher furnace temperatures and more complete combustion, thereby reducing smoke and grit emission. In addition, preheated air was to be supplied to the mills to reduce the excessive moisture content which had proved troublesome in the initial stages of lighting up the boilers. The net result of these improvements was expected to be that additional steam could be generated, with a measure of control of superheater temperatures, for boosting the station output at times of peak load.

Last week we were able to visit St. Pancras power station to see the embodiment of this scheme in an oil burning installation carried out by Fuel Firing, Ltd., Woodley, Reading, Berks. The oil burners consist of the company's "FF2A" Initiators, which, as illustrated herewith, are fully retractable from the furnace, so that when the burners are not in use the precision parts making up the atomiser are protected from grit and ash and the radiant heat of the furnace. These Initiators are fitted on the four boilers as tabulated herewith. One of our illustrations shows the three units fitted on No. 7 boiler.

Oil Burner Units at St. Pancras Power Station

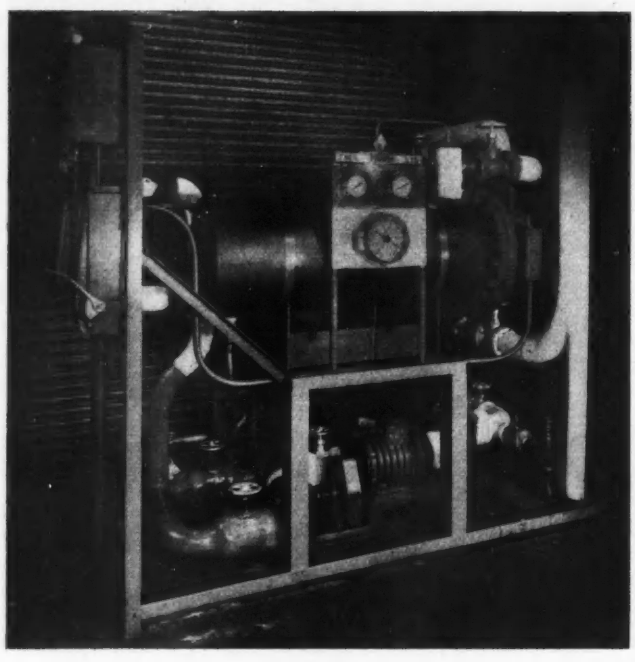
	Steam pressure, lb/sq. in	Steam temperature, deg. Fah.	Original capacity, k/lb/hr.
Four on No. 5 boiler	220	660	55
Two on No. 6 boiler	220	660	55
Three each on Nos. 7 and 8 boilers	220	695	50 each

The burner unit consists of a central sprayer tube carrying a Lucas atomiser, which was developed originally for gas turbines. This atomiser consists of three mirror ground plates. The first plate carries a row of small orifices disposed on the circumference of a circle. The forward face of this plate has a circular groove which provides communication between the orifices when the plates are butted together in the assembled atomiser. The middle plate has two circular holes on a diameter and there is a central hole with a radial channel communicating with each of the outer holes. These outer holes register with the pitch circle of the orifices in the first plate and the inner hole is likewise concentric with a small orifice in the third plate, which constitutes the final jet. This assembly has been found to give very good atomisation.

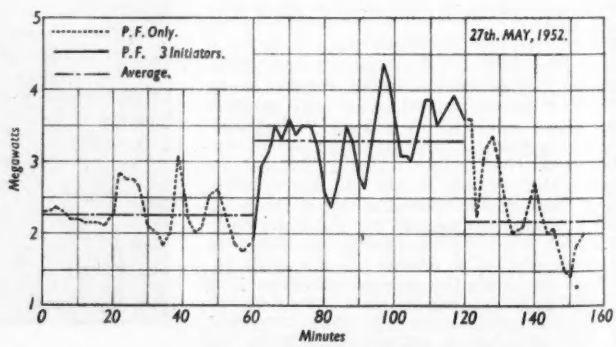
Around the sprayer tube there is a sleeve with shaped slots near the atomiser end. It carries primary air for maintaining stable ignition under any furnace conditions and for keeping the atomiser cool; the scouring action of the primary air stream tends to prevent the deposition of carbon and therefore reduces the need for cleaning. Secondary air is introduced through a swirler which consists of a cylindrical sheet steel chamber about 1ft in diameter. Suitably profiled blades are arranged round the periphery at one end of the swirler to create the turbulence required for satisfactory combustion of the oil. The outer tips of the blades are welded to one end of the swirl chamber and the inner blade tips are similarly welded to a circular ring.

The atomiser, sprayer tube and swirler are housed in a cylindrical shell, which is mounted on a shaft carried in two bearings fixed to the main framework as shown in our illustrations. The bearings form a horizontal axis about which the complete burner unit can be rotated bodily into and out of the furnace. One of our illustrations shows the unit in three positions—fully retracted, on the left; entering the furnace, centre; and in the operating position, on the right. This illustration also shows the closing plates whereby furnace opening is sealed whether the burner is in or out. The closing plate for the retracted position slides vertically in guides, is counterbalanced and is operated manually.

There are two forced draught fans (one for



Oil Pumping and Heating Plant



Test on No. 8 Boiler

each pair of boilers) to supply the pressure air requirements of all the burners. No provision is made for varying the output on individual burners and any variation in output is achieved simply by cutting in or out the individual burners. Thus a constant air/fuel ratio is maintained on each burner to suit its designed duty.

Combined observation and access is provided in the closing plate when the burner is in commission. Ignition of the oil is obtained by hand torch on initial starting. Interlocks are provided on the oil supply to the Initiators to prevent the possibility of the burner being retracted whilst alight, and the air supply to the burner is automatically put on and shut off by the rotation of the burner itself, thus eliminating the necessity for individual dampers.

One of the interlocks can be seen on the right of the burners in the accompanying photographs. It is a fuel valve operated by a handle having a projection which engages with a quadrant plate on the burner casing and ensures that the fuel cannot be turned on unless the burner is in the operating position.

The fuel capacity of each burner is 400 lb of oil per hour and each unit is therefore capable of supplying sufficient heat for the generation of 4200 lb of steam per hour.

The oil burnt is heavy fuel oil of 960 seconds Redwood No. 1 viscosity, supplied to the station by road tanker and delivered at a temperature of 100 deg. Fah. into two storage tanks of 30 tons total capacity.

The temperature of the oil in the storage tanks is maintained at approximately 100 deg. Fah. by steam-heating coils and the fuel is drawn from these tanks direct to a pumping and heating unit, which is illustrated herewith. It incorporates two positive displacement pumps giving a constant delivery pressure of 200 lb per square inch to the oil range. The oil is delivered to the burners from the pumps through thermostatically controlled electric heaters giving a total temperature of 200 deg. Fah. at the outlet of the unit. A suction strainer is provided in the inlet of the heater and a fine mesh self-cleaning filter is installed in the outlet to the range. The oil range is of a loop design to allow recirculation of the oil for constant temperature and the supply to each burner is by individual connections controlled with stop-valves.

Some details of operating experience with the new equipment were given, during our visit to the power station, by Mr. J. H. Ramsden, station superintendent, and Mr. C. C. Hitchin, generation engineer (operations), group 3, London Division, B.E.A.

The installation of oil burners at St. Pancras power station has greatly simplified lighting-up procedure : by using three or four burners across the boiler, instead of lighting-up on one pulverised fuel burner only, more even heating is obtained. Present experience shows that there is less tendency towards overheating of superheater tubes and suggests the possibility of achieving finer control of furnace temperature. Rapid air heating and coal drying is a characteristic of the new installation.

It was anticipated that the effect of the oil boost on the refractories would be severe and would increase the cost of renewals. Operational experience through the winter period indicates that such fears were unjustified, although comparative observations show that the furnace temperature has increased from 2300 deg. to 2600 deg. Fah. Perhaps the most significant aspect of operational experience with the oil burning equipment is the load boost obtained at periods of peak demand. The output capacity of the station immediately after its annual overhaul and before the use of oil, was 24MW sent out. As indicated by the curve opposite, the capacity with oil is 27MW sent out, which represents an increase in capacity of 3MW at a capital cost of slightly less than £2 per kW for the oil burning installation. Concurrently there has been a fall in the fuel cost per unit sent out and in the thermal efficiency, but these improvements cannot readily be expressed numerically since they are the result of a number of improvements besides oil burning which have been carried out at St. Pancras station.

However, there is evidence to show that the higher furnace temperature is giving a nearer approach to complete combustion, with a consequent improvement in efficiency and a reduction of carbon-in-grit carry over. The reduction in smoke and grit emission is vouched for by independent observers interested in smoke abatement and is matched by a marked improvement in the cleanliness of the stack.

Fiftieth Anniversary of the Metropolitan Water Board

THE fiftieth anniversary of the first meeting of the Metropolitan Water Board occurred yesterday, April 2nd, and the Board celebrated this event with a luncheon and a special meeting on Friday last, March 27th. As many of our readers will know, the chief engineer of the Metropolitan Water Board, Mr. H. F. Cronin, is this year's president of the Institution of Civil Engineers. Mr. Cronin's presidential address of last November comprised an account of the history of London's pumped water supply, and in an abstract from that address, printed in THE ENGINEER of November 7th last, details of the development and operation of the Metropolitan Water Board during the past fifty years were given. The brief history of the Board's activities which we print below is, therefore, confined mainly to the general problems of administration.

During the latter part of the nineteenth century the water supply to London and its environs was in the hands of eight statutory water companies which had come into being over a period of nearly 300 years. Important questions concerning the adequacy and purity of the water supplied and the management of the companies' undertakings pressed themselves with increasing insistence upon the public and Parliament and a number of remedial measures were taken. Three Royal Commissions examined the water question in great detail, in 1869, in 1893, and in 1899. The last Commission came to the conclusion that, having regard to the magnitude of London's future water requirements, the concentration of the undertakings into the hands of one authority was desirable, and recommended the establishment of a water board for that purpose. The London Water Bill was subsequently introduced into the 1902 session of Parliament, and it reached the statute book on December 18th as the Metropolis Water Act, 1902.

The newly-created Board was at once confronted with what was probably the biggest arbitration on record at that time and this task overshadowed all others during the first year of office. The claims of the water companies amounted in all to £50,939,898. The Court of Arbitration awarded £30,662,323 in cash in respect of the transfer of the undertakings, to which sum a number of other items had to be added, bringing the total cost of acquisition to £46,939,258. The provision which has to be made for extinguishing the "acquisition debt" by the year 2003 is one of the principal items of the Board's annual expenditure. From the "appointed day" until March 31, 1952, the Board has spent some £28,600,000 on extending and improving the undertaking. Works at present in hand are estimated to cost some £8,500,000. The Act of 1902 placed upon the Board the obligation to promote within three years from the "appointed day" a Bill providing for uniform scales of charges applicable throughout the limits of supply. This was a matter of some complexity. Varying scales of charges for domestic supplies operated in the companies' areas and numerous other differences and anomalies were prevalent. The Board's charges scheme, as submitted to Parliament, provided for the assessment of water charges on the basis of the rateable (now net annual) value of the premises supplied and with some modifications became the Metropolitan Water Board (Charges) Act, 1907.

The succeeding years to 1921–22 were years of financial deficiency, and frequently the Board was called upon to consider complaints regarding the method provided in the Charges Act of 1907 for the liquidation of deficiencies in the Water Fund. The administration of the Board was the subject of much unfriendly criticism. In 1919, at the request of the Board, a Committee of Inquiry was appointed by the Minister of Health to investigate the working of the Board, which vindicated the Board's methods of management. The Metropolitan Water Board (Charges) Act of 1921, largely based upon the Committee's proposals, enabled the Board to improve its financial position and so to carry out effectively its statutory obligations. By 1939 the water rate had been reduced by successive stages to 5¾ per cent of the net annual value of the premises supplied. The rate was raised to 7 per cent for 1940–41 and to 8½ per cent for 1941–42, at which figure it remained until March, 1947. It was necessary to raise the rate to 9 per cent for the year 1947–48 and, the year following, to 10 per cent, at which level it has since stood except for the two years 1950–51 and 1951–52. The current rate of 10 per cent is the maximum which the Board is empowered to charge.

With the transfer of the several undertakings of the companies the Board inherited a large number of engineering works of great diversity, and also a variety of schemes, some of which were in course of construction and some only on paper. The maintenance of the existing supply was, of course, the primary task, but the Board soon addressed itself to its next duty, namely, that of providing for the future needs of its consumers. In 1907 the Board endorsed the conclusions of the Commissions of 1893 and 1899 regarding the adequacy of the Rivers Thames and Lee. Since then the provision of storage accommodation in the valleys of these rivers has been pursued with vigour. The King George's reservoir at Chingford was completed in 1913, the Queen Mary reservoir at Littleton in 1925, the King George VI reservoir at Staines in 1947, and the William Girling reservoir at Chingford in 1951. These reservoirs have increased the Board's storage accommodation by 17,000 million gallons. Work on a new reservoir at Walton, which began in 1939, is still in abeyance, as is also the construction of two further reservoirs at Datchet and Wraysbury, for which powers were obtained in the Board's Act of 1946.

Many of the works have been remodelled and others substantially altered by the installation of new machinery. The most noticeable example is at Hampton, where, at the turn of the century, three of the water companies had engineering works of one kind or another. At these works one engine-house has been constructed into which has been concentrated the work previously performed in eight pumping stations. In addition, much of the filtration plant has been reconstructed and primary or rapid filters have been installed. New filtration works include an entirely new filtration and pumping station in the Thames Valley capable of producing 90 m.g.d. of filtered water. The slow sand filter beds at this station, and certain other parts of the work, have been completed. Primary filters, an adjunct to the slow sand filter process, have been installed at a number of works since 1922.

The distribution system throughout the 540 square miles of the Board's area of supply has, of course, been strengthened and extended. Over 2500 of the present total of 8500 miles of mains have been laid since 1903 and the distribution networks of the former companies have been integrated. At the present time the construction of a 60in main which will convey water from the Thames Valley to the Western area is nearing completion. The supply from underground sources has been augmented by the construction of twenty wells or bore-holes with their attendant pumping stations.

The changes which have taken place in the work of examination and purification of the water since the Board's early days have been of a far-reaching character. The Board was anxious to place the examinations on a uniform basis and accordingly, in 1905, a laboratory for the analysis of samples and research was established. In 1916 pre-chlorination on a large scale was introduced at Staines. In 1921 terminal chlorination was first used by the Board. In 1936 all water passing into supply was treated by ammonia and chlorine. In 1948 this process was superseded by "superchlorination," which has had a more profound influence upon the physical quality of the water and its bacterial purity than any other measure since the introduction of sand filtration and has effected a marked saving in cost. Samples of water from all points of the system are analysed, many of them daily, at the present laboratories at New River Head, which were opened in 1938.

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"THE LION HAVING REACHED HIS HEAD . . ."

When, in 1947, soon after the end of the war, the first "Economic Survey" was published it was hailed by every reader as a valuable forecast of coming developments. Since then a new "Survey" has appeared each spring. But how many would assign much value to the "Economic Survey for 1953" as a forecast of events to come? In truth the character of the "Surveys," under the battering of real events, has gradually altered. Those, whoever they may be, who compile them, have steadily lost the high confidence which was theirs at the beginning. The original "Survey," having reviewed the year just gone, proceeded, building upon that base, to forecast in some detail and with apparent confidence economic changes in the coming year. It laid down production targets for various industries, predicted changes in employment, pointed out that the targets could not be reached without redistribution of manpower between one industry and another, and worked out, indeed, a general plan for the development of the whole economy of the country. But in the following years, under the blows of unforeseen financial crises, and the repeated refusal of the economy to develop in the predicted way, confidence, like poor Jim in the *Cautionary Tales*, was eaten away. "Now just imagine how it feels when first your toes and then your heels, And then by gradual degrees your shins and ankles, calves and knees, Are slowly eaten bit by bit; no wonder Jim detested it!" In 1953 little more is left than the fount and origin, the head, from which all else used to follow. Out of some fifty pages over forty review the events of 1952. What is said about 1953 is contained for the most part in such trite sentences as "Over a large part of the economy the course of production in 1953 seems likely to depend on what happens to demand at home and industry's success in selling abroad" and—upon coal supplies—"the outcome in 1953 seems likely to depend in the main on the success of the drive to increase production . . ." In fact, in relation to its presumed intention as a forecast and a plan, the "Economic Survey for 1953" has become very like poor Jim: "The lion having reached his head, the miserable boy was dead!"

Looking back, with all the wisdom that knowledge of events has brought, it now seems curious that it should ever have been thought possible that the economic events of a future twelvemonth could be seen more clearly than through a glass darkly, or that economic developments could be at all closely planned in a democracy. For it is only dictators wielding unlimited controls and prepared inhumanly to move whole populations from one area to another or to change their occupations overnight who can lay down rigid forecasts or prepare five-year plans; and even they can only do so in nations whose economies are more or less self-contained. In a democracy, particularly a democracy so dependent upon worldwide trade as is ours, the thing is clearly impossible. The trade of this country and consequently its economic development is closely affected, not only by home affairs, which may or may not be under some degree of Governmental control, but also by far-away events, the outbreak of war in Korea, the occurrence of a drought in Australia, racial upheaval in Africa, and the unpredictable decisions of foreign politicians to free trade here or restrict it there. Neither extension of controls in the United Kingdom nor the nationalisation of basic industries, nor the operation of fiscal machinery, can have a bearing on such events. All that a British Government can really do is to create an atmosphere conducive to the development of the economy in a desired direction. Conceiving that productivity must be raised if the standard of living is to rise, it can encourage the setting up of a Productivity Council; believing there are too few technologists, it can devise schemes for improving education; aware of the necessity to balance overseas trade, it can restrict imports and encourage exports; convinced by the run of events, that the heavy engineering industries must carry a greater burden of exports than ever before, it can relieve some of the home demand by spreading defence production over a longer term of years; fearing inflation, it can bring about restriction of credit, thus directing investment into channels likely to be more immediately rewarding; and where it has more direct control, it can restrict capital expenditure, as upon the roads, or encourage it, as in the coal mines. It can hope for results from such actions. But as experience since the war has shown, it can never confidently predict those consequences. Unforeseen events and unexpected human reactions may defeat its aims.

Nowhere is a British Government less able to control events, but nowhere can it more beneficially influence Britain's economy than abroad. As the "Economic Survey" reveals, the basic economic situation of this country has hardly changed since the war. We still need to expand exports, more particularly to the dollar area; the central reserves of the sterling area are still too small to take up, without the occurrence of a monetary crisis, inevitable fluctuations of trade. But to build up exports, to restrict imports and so to collect a more adequate reserve in a world in which many another nation is trying to do the same is only possible by international agreement. Without that agreement a tariff and quota war would inevitably ensue. Particularly is agreement needed with the United States. For so long as that country continues to export whilst discouraging imports by tariffs, by customs practices and by a general attitude of mind, so long will the monetary reserves of other countries be under pressure. There is wide appreciation in Washington, New York and other eastern cities of the United States of the true role in world economics of a creditor nation. But the much more parochially-minded Mid-Westerners, convinced that no other nation can make goods that compare with the American, still fail to appreciate that they cannot export to the world unless they also buy from it and that the attempt to do so can only impoverish, not enrich, their country. The British Government can play a part in bringing about a change of mind. But it cannot predict when, if ever, the change will occur, nor plan in any detail for its occurrence. A growing realisation of the powerlessness of democratic Governments to control economic events, great though their influence can be upon them, has been reflected in the evolution of the "Economic Surveys." This year the wheel has turned almost full circle. The "Economic Survey for 1953" scarcely has relevance to the year to which it is supposed to refer. It would have been better entitled "Economic Review of 1952." For in that capacity it serves a really useful purpose.

LOCOMOTIVE REPAIRS AND RUNNING

"There is no more important part of the railway mechanical engineer's activities than the maintenance of the locomotives provided to work the traffic, from which the revenue of the undertaking is mainly obtained, and by which a great national service is rendered to the country." Such were the opening words of a comprehensive paper read before the Institution of Locomotive Engineers on Wednesday, March 18, 1953, by Mr. R. C. Bond, chief officer (locomotive construction and maintenance), the Railway Executive, describing the organisation and control of locomotive repairs on British Railways.

The great railway workshops of this country, at Crewe, Doncaster, Eastleigh, Swindon, and elsewhere are famous as the birthplaces of many locomotives that have achieved worldwide renown; but, as Mr. Bond emphasised, new construction is a relatively small part of their work, and it is as repair shops that their function is becoming increasingly vital. Since nationalisation an attempt has been made to begin standardising methods, as between one works and another, in rationalising the load on each works by concentrating repair work on engine classes used in two or more regions at one centre, and by laying down a unified code of principles by which engines are proposed and accepted for shopping. The prime object is, of course, to work the traffic with the minimum number of locomotives, and to this end to secure an increased mileage from each locomotive between periodical repairs, and to execute those repairs in the shortest possible time. Allied with these two axioms is a third—not directly connected with repair organisation—that of arranging duty rosters so that engines can do the maximum amount of work in any twenty-four-hour period. Mr. Bond followed up his exposition of the principles upon which his organisation is based by a detailed reference to the practice at Crewe, which works had been a particular responsibility of his for many years prior to nationalisation.

Although standardisation on a large scale, with the elimination of many of the older individual locomotive classes, is the ultimate ideal, the present stage, five years after nationalisation, is extremely interesting. Enough has been done to bring the performance records of some of the older locomotives under common headings; the details of mileages run between periodical repairs, as given in Mr. Bond's paper will inevitably give rise to comment and comparison, and there is a great temptation to relate such results to details of design, as between one of the former railway companies and another. This is the more understandable when it is seen, for example, that the fitting of manganese steel liners to the horn guides on a group of Stanier class "5" mixed-traffic 4–6–0s of the former L.M.S. increased the mileage of those engines between repairs to an average of 97,291, from the average of 56,969 applying to the rest of that numerous class. Similar improvements have been shown by certain engines of the ex-L.N.E.R. "A1 Pacific" class which have been fitted with roller bearings on all axles. In general, however, it is the locomotives of the former Great Western Railway that show up best in this comparison. Apart from the "Castles," which show considerably the highest mileage of any class "7" express passenger design, there is the remarkable case of the "2800" class of 2–8–0 freight engine. Whereas the comparable 2–8–0 locomotives of other regions do not rise above 62,600 miles between periodical repairs, the figure for the "2800" class is no less than 86,981 miles—very little below that of the "Castles" and of the Western Region 4–6–0 mixed-traffic types. Figures relating to the new British Railways standard locomotives are, of course, not yet available, as very few have yet reached the stage of their first general overhaul.

Although the mileage run between periodical repairs can be regarded as one very sound measure of locomotive performance, it would not be correct to attribute all the differences to points of design. From the discussion that followed Mr. Bond's paper it was fairly evident that standards of work vary in different parts of the country, and one speaker went so far as to suggest that the performance of a particular class in relation to matters of design should be judged, not by the average of the whole stud, but by the work of the ten best engines. Deterioration beyond this level was, he stressed, a works and motive power matter. Without this evidence of individual variation it might have been a little disconcerting to see that locomotive classes repaired at works where the admirable system described by Mr. Bond had been longest in operation made, almost without exception, the poorest showing, so far as mileages between periodical repairs were concerned. It will be extremely interesting to see how the new British standard locomotives compare with the best of the regional types when sufficient mileage has been amassed to make the data reliable. The use of manganese steel liners on the wearing surfaces of the frames and on the axleboxes at the faces in contact with the guides has yielded an almost sensational improvement in the case of the Stanier 4–6–0 engines, and as the new standard engines are similarly equipped we may well look forward to seeing mileages in excess of 100,000 attained. In view of the savings in repair costs thus represented, it would surely pay to add this refinement to some of the best regional types which have still many years of useful service to give. It is intended, for the present, to confine the new standard engines to the particular works at which they were constructed, so far as periodical repairs are concerned, even though they may be in service on three or four regions, as in the case of the "Britannia Pacifics." The latter will, for example, all be sent to Crewe. The subsequent mileage of individual standard engines will be to some extent an index of running conditions in the respective regions to which they are allocated. In his reply to the discussion, Mr. Bond, although viewing the task as a whole, on a national basis, freely admitted the differences in standards of work at present existing in different parts of the country, and in so doing he paid a handsome tribute to the practice of the former Great Western Railway, which for accuracy in construction and in soundness of repair work, he said, was unsurpassed.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

INSTALLATION OF LONG CONDUCTOR RAILS ON SOUTHERN REGION

SIR,—I refer to the very interesting article in your issue of March 6th on the "Installation of Long Conductor Rails on the Southern Region." The article refers to the possible future development whereby the ends of the 180ft current rails will be joined by electric arc or oxy-acetylene welding (at site) into continuous rail lengths of ¼ mile, thus enabling a saving of ½ ton of the copper used in bonds per mile. It also mentions that this development is contingent on an adequate supply being available of special anchor units and expansion bonds.

It will, I think, be of interest to your readers to have placed on record that the standard arrangements for conductor rails on London Transport tracks have provided, since 1945, for conductor rails to be sent out from the workshop welded into 300ft lengths and for these to be arc welded together on site into continuous lengths of 800 yards, which are anchored by special anchor units at the mid-point.

Incidentally, the methods of handling and installing the rails which have been in use since 1945 closely resemble those now developed by the Southern Region of British Railways.

P. CROOM-JOHNSON,
Chief Engineer,
London Transport Executive,
55, Broadway, Westminster, S.W.1,
March 26th.

TEMPERATURE CONVERSIONS

SIR,—It may be that there are a few engineers who, like myself, sometimes have to think twice before converting Centigrade readings to Fahrenheit, as to whether to add or subtract 32 before or after multiplying by either 5/9 or 9/5! For their benefit, and for that of students who have not yet acquired bad habits, may I offer a method which was told to me years ago; which is, I think, easier to remember, and which does not appear to be generally known. Given any temperature, positive or negative, Centigrade or Fahrenheit, apply the following rules: add 40; multiply by 5/9 or 9/5; subtract 40.

The underlying fact is, of course, that —40 deg. is the same temperature in either system.

C. E. M. CRITCHFIELD, M.I.Mech.E.
London, S.W.20, March 23rd.

LOCOMOTIVE CYLINDER RELIEF VALVES

SIR,—I should like to thank Mr. Cardew for his interesting letter of February 18th. As Mr. Cardew surmised, I was ignorant of the principle of the Cardew relief valve. Although I have rarely missed a copy of THE ENGINEER for the past thirty years, I have never seen any reference to these valves. Could Mr. Cardew give a drawing showing some details of their construction?

The only cylinder relief valves with which I am familiar are of the orthodox spring-loaded safety valve type which do not commence to open until the clearance space is filled with water trapped by the advancing piston, i.e. until the danger point has been reached. The Cardew relief valves are not unlike "pop" type safety valves, and as they are operated by the kinetic energy of the water columns set in motion by the inflowing steam they release condensate almost immediately it forms. The photograph published bears testimony to the effective discharge from these valves. It would be interesting to know why these excellent relief valves have not been adopted by other engine builders and designers, and why hand-operated cylinder cocks and ordinary relief valves have not been discarded on the New South Wales Railways.

With regard to cylinder cover breaking grooves, the description of the new Beyer-Garratt engines gave the impression that both front and back covers were provided with grooves. From Mr. Cardew's letter it appears that only the front covers have breaking grooves, presumably because any back cover failure would prove disastrous and wreck the cylinder involved.

On various occasions I have written letters with the object of inducing designers, and others, to impart information of interest. I believe it correct to say that only Mr. Cardew has taken the trouble to reply, and I feel sure that many readers will be interested in his letter and pleased to see a drawing of his relief valve.

E. B. PARKER
Wirral, Cheshire, March 19th.

Obituary

SIR DAVID ANDERSON

We regret to record the death of Sir David Anderson, which occurred on March 27th, at his Scottish home, Dura House, Cupar, Fife. Sir David was president of the Institution of Civil Engineers in the session 1943-44, and was well known for his work on the design of bridges and tunnels. He was born on July 6, 1880, at Leven, Fife, and his general education was at Dundee High School ; he studied civil engineering at St. Andrew's University and obtained his degree (B.Sc.) there in 1900. He then served a period of practical training first at the Glasgow works of Sir William Arrol and Co., Ltd., and later, in 1905, he came to London and served under Sir Benjamin Baker.

Sir Benjamin Baker had delegated the construction work on the widening of Blackfriars bridge to Mr. (later Sir Basil) Mott, and Sir David was appointed resident engineer for that widening work in 1906. Sir Benjamin died early in 1907. Sir Basil Mott had been associated for some years with Sir Benjamin on the design of the City and South London tube railway and the Central London tube railway, and Sir David took part in many later works on these railways. He was also engaged on several important bridge works at about this period, notably the new Southwark bridge across the Thames and, at Rochester, the bridge across the Medway. He was chief assistant to Sir Basil Mott at that time. In the first world war Sir David served in the Royal Engineers and completed his military service as a captain.

In 1923 he became a partner in the firm of Mott, Hay and Anderson, and from that date until his death he continued in practice as a consulting engineer. Sir Basil Mott and Mr. David Hay had been in partnership for a number of years prior to 1923, and had been responsible for some important bridge and tunnel works. The firm entered a period of great activity following the war, and Sir David, in collaboration with his partners, was concerned with the design and construction of numerous important projects for bridges and tunnels. The best-known of them was, undoubtedly, the Mersey tunnel between Liverpool and Birkenhead, which was opened after about nine years' work, by H.M. King George V in 1934. The Mersey tunnel was the first subaqueous vehicular tunnel to be built in this country since the internal combustion engine revolutionised transport on the roads ; it was the largest work of its kind in the world, with a length between portals of 10,584ft, the length with branches being 13,800ft, and was considered a masterpiece of its kind. A description of the design and construction of the Mersey tunnel, and a statistical comparison with other contemporary tunnels was given in our issues of July 13 to 27, 1934. However, the firm was also concerned with other tunnel projects of some magnitude, including the Dartford-Purfleet tunnel under the River Thames. This work was started and the first part of it—the pilot tunnel—was completed, but the construction of the full-size vehicular tunnel was deferred and has not yet been started. Sir David's firm was associated in this work with Messrs. Coode and Partners.

Sir David's firm also carried out a great deal of work on London's underground railway systems ; two of their achievements may be given by way of example—the North-Eastern extension of the Central line, the Ilford extension, as it is sometimes called, and, earlier, the Morden extension of the Northern line. With the austere conditions which have prevailed since 1945, new tunnelling works have been virtually at a standstill ; however, the paper presented by Sir David at the 1951 Joint Engineering Conference, entitled " Underground Railway Planning and Construction," described some new works which have been designed, although they have not yet been built, and gave an interesting survey of the problems faced to-day in the construction of new underground lines. A particularly interesting discussion was stimulated by Sir David's paper, as noted in a leading article in our issue of June 22, 1951. Apart from the London underground, one post-war tunnelling work should be mentioned here—the vehicular tunnel under the River Tyne. The pedestrian tunnel of this scheme is now in operation, but the vehicular tunnel has not yet been built.

Apart from the design of tunnels and bridges, Sir David's firm has, in recent years, undertaken the civil engineering design of several of the British Electricity Authority's new power stations, notably at Bankside and Deptford in London, and at Ferrybridge, in Yorkshire. Sir David's position as senior partner of the firm brought him no little responsibility for these works, as with all the schemes which the firm undertook. But one of his principal interests lay with the design of several ambitious projects for bridges. The Severn suspension bridge, designed by Sir David's firm in collaboration with Messrs. Freeman, Fox and Partners, has been described in these columns on several occasions, and will be familiar to many readers on account of the extensive wind tunnel tests carried out on models of the bridge. Another design for a long-span suspension bridge upon which he was engaged was that of the bridge across the River Forth. Construction of these bridges has not been possible under existing Governmental policy, but we understand that work will soon be commenced on another bridge project with which Sir David was particularly concerned, the proposed bridge across the River Mersey and the Manchester Ship Canal between Runcorn and Widnes.

Sir David Anderson

Sir David Anderson's work included service on a number of technical committees for the Government, some of them of no little importance. He was chairman of the Professional Institutions' committee on improved Methods of Steel Utilisation, which was set up by the Ministry of Works in 1949, and included in his other work of this nature was membership of the committee assisting Sir John Anderson (now Lord Waverley) on shelter policy prior to the war. Sir David was technical adviser to the Minister of Home Security during the war, and he was a member of the Building Research Board of the D.S.I.R. He was created a Knight Bachelor in 1951, and in 1936 he received an honorary degree of LL.D. from the University of St. Andrews. He was a member of the American Society of Civil Engineers, and the author of several papers read before the Institution of Civil Engineers. As mentioned earlier, he was president of the Institution in the session 1943-44 ; his presidential address in that session was of particular interest, in that it was concerned, not with purely technical matters, but with the part which engineers should play in the direction of the country's affairs generally, a subject upon which Sir David held firm and progressive views. The skill and ingenuity that had been used for purposes of destruction in time of war could and should be used, Sir David emphasised, for purposes of construction and improvement in times of peace. The heavy responsibilities carried by the modern civil engineer were largely ignored by the modern layman, he contended. " It is high time," Sir David said, " that the engineer who has perhaps rashly and blindly created modern life, should now be associated with the control of it and help in directing its future shape. Let all of us refuse to sink into the position of being merely technicians—of which there is a real danger in our absorption in our profession ; let us rather take the position of planners and leaders. We shall need to equip ourselves for such a position. That is a difficult problem and will require careful consideration."

SIR ARTHUR SUTHERLAND, Bart.

It is with regret that we record the death of Sir Arthur Sutherland, Bart., K.B.E., D.C.L., in his eighty-sixth year, which occurred on Sunday, March 29th. Arthur Munro Sutherland, who was a leading ship owner and coal exporter and closely associated with both the civic and commercial life of Newcastle upon Tyne, was born on October 2, 1867, and was educated at the Royal Grammar School, Newcastle, of which he was later to become a Governor. He was engaged in the business of shipping all his life and, from early beginnings with a shipbroking firm, he went on to achieve considerable success in the field of commerce and, by his industry, business acumen and sound judgment of the shipping market, established the cargo shipping company of B. J. Sutherland and Co., Ltd. As a prominent shipowner, Sir Arthur was closely connected with national bodies concerned with shipping and was president of the Chamber of Shipping in 1930 and occupied the same position with the Shipping Federation for the space of twelve years, from 1938 to 1950. He was also a member of the committee of Lloyd's Register of Shipping and of the Worshipful Company of Shipwrights. Sir Arthur took an active interest in the civic affairs of Newcastle upon Tyne and served on the City Council for a number of years, becoming Sheriff in 1917 and, two years later, was elected Lord Mayor. In 1943 he held the office of High Sheriff of Northumberland and for some time was a Justice of the Peace for the City and County of Newcastle, of which city he was given the honorary freedom. He was a generous subscriber to public funds and provided considerable sums of money towards the cost of forming medical and dental schools in the city as part of the University of Durham. In addition to being chairman of his own shipping company, Sir Arthur was associated in that capacity with Donkin and Co., Ltd., and was a director of John Bowes and Partners, Ltd. He also served a term as chairman of the Tyne Improvement Commissioners and of the Newcastle and Gateshead Chamber of Commerce. Shortly after the first world war he was made a K.B.E. and one year later, in 1921, was created the first baronet; he was also honoured by being appointed Knight Commander, with star, of the Order of St. Olaf, Norway.

DR. GUTHLAC WILSON

Many civil engineers, particularly those connected with soil mechanics and with structural engineering, will have learned with regret of the death of Dr. Guthlac Wilson. Dr. Wilson and his wife were passengers in the "Viking" aircraft which crashed last Sunday during a flight from Nairobi to Blantyre, along the Tanganyika coast, with the loss of all the passengers and crew. Dr. Wilson was the senior partner in the consulting firm of Scott and Wilson, and was well known as an authority on soil mechanics and foundation engineering.

Dr. Wilson was born in London in 1902 and received his engineering education at East London College, which is now Queen Mary College, obtaining his degree in 1921. He was then employed by Sir Robert McAlpine and Sons, Ltd., for about two years, after which he went to India with Braithwaite and Co. (India), Ltd. His career with this firm, and with the Braithwaite, Burn and Jessop Construction Company, continued in positions of increasing responsibility until 1938, when he went to Harvard University for a course of study; he was awarded a fellowship at Harvard in the session 1939–40, but he discontinued his studies to return to this country on the outbreak of war. However, his work at Harvard earned him a Master of Science degree (S.M.), and was doubtless valuable in promoting his knowledge of soil mechanics. From 1939 to 1945 Dr. Wilson held the post of Director of Constructional Design at the Ministry of Works. At the end of the war he became a partner with the late Mr. W. S. Scott in the firm of Scott and Wilson, becoming senior partner on Mr. Scott's death in 1950.

During the course of his career Dr. Wilson obtained a very wide experience of foundation problems and soil mechanics, and in the design of numerous engineering structures. Much of his work was embodied in papers presented to various learned societies, principally to the Institutions of Civil and of Structural Engineers, which were largely concerned with various aspects of soil mechanics and its applications. Of recent years his firm has shown a tendency to participate more in heavy civil engineering work, and in civil engineering schemes in overseas territories, trends which were doubtless accelerated by Dr. Wilson's influence. Of the many works carried out during the past few years by his firm, one or two examples may be given of constructional schemes in which he was particularly interested. They include, in this country, such works as the design of the British Nylon Spinners factory and extension at Pontypool, and the Churchill Gardens housing estate of the Westminster Council at Pimlico, to mention only two; overseas, the development in Nyasaland of roads, airports and water supply may be mentioned, as well as the project for Kai Tak airport in Hong Kong.

Dr. Wilson served on a number of important committees and governing bodies, of which membership of the Road Research Board and of the Ministry of Works National Consultative Council of the Building and Civil Engineering Industries may be mentioned. He was a member of council of the Institution of Civil Engineers and of the Association of Consulting Engineers. He was awarded a doctorate of engineering by London University in 1951.

Non-Ferrous Research Laboratories

Visitors to the laboratories of the British Non-Ferrous Metals Research Association at Euston Street, London, N.W.1, were able last week to see working some of the latest forms of research equipment, which are installed there. Some forty-two major research projects are at present under investigation, and last year members received help in connection with over 980 technological problems.

The B.N.F.M.R.A. started in 1920 with a membership of twenty firms and an income of £6000. It now has a membership of 600 firms and an income of nearly £128,000. Nevertheless, the Association maintains that, although almost all the major firms in the non-ferrous metals industry are members of the Research Association, including many engineering firms who are merely users of non-ferrous metals, there are still many small and medium firms in the industry who do not take advantage of membership. In many cases, it is these firms who would benefit most from wise use of the facilities the Research Association provides.

It has been estimated, for example, that there are over 1000 brass and bronze foundries up and down the country, but not more than 5 per cent of these belong to the Research Association. Yet the Association is well known for its researches into non-ferrous foundry practice and could undoubtedly give much-needed technical assistance to all these foundries. In this field, the Association has recently been responsible for the introduction into the foundry industry of a special insulating feeder sleeve, which enables a much smaller feeder head to be achieved. These sleeves are made from a newly developed foamed plaster of Paris which is as permeable as sand. They are inexpensive and enable the yield of metal melted compared to the weight of finished casting to be increased in some cases from about 50 to 80 per cent or more.

There is scope for a lot of work of this kind, the Association states, but it can only be carried out to the extent to which the industry is prepared to finance it. As metallurgy is now a complex branch of science drawing on the knowledge of the physicist, chemist and engineer as well as the metallurgical specialist, few firms can afford to maintain such specialists and the necessary equipment, all of which are available to even the smallest member through the resources of the Research Association. In addition, the Association maintains a team of men experienced in the interpretation of modern research who can, and do, assist members to take full advantage of the latest developments in technology and research.

Report on the Collision at Guildford Station

The Ministry of Transport report has now been published on the collision which occurred on the Southern Region at Guildford Station at 10.34 p.m. on Saturday, November 8th last. The collision took place when a light engine running tender first on the down Guildford–Alton line at a speed of about 5 m.p.h. was struck by a two-coach electric passenger train moving at a speed of about 40 m.p.h. The passenger train was the rear section of the 8.45 p.m. train from Waterloo, which was divided at Ascot, and formed the 9.46 p.m. Ascot to Guildford train. This train got out of control on the falling gradient from Pink's Hill owing to the failure of the brake, due to loss of air after a compressor fuse had blown. The train ran past the Guildford Yard up outer and inner home signals at danger and then entered the down line through a crossover already set for the light engine. The motorman and one passenger were killed and thirty-seven persons injured or suffered from shock. In his report Brigadier C. H. Langley states that this accident was of an unusual kind and that it was the first time a Ministerial inquiry had had to be held into the failure of a Westinghouse brake on electrified stock. Tests carried out in the investigation showed that this type of air brake was highly efficient and no fault could be found with it. It seems that the driver did not notice the drop in pressure in the duplex gauges which register the air pressure in both the train pipe and the main reservoir. As this was a two-car train it was served by a single compressor, on the failure of which the air in the main reservoir alone was left for braking purposes. The report states that steps are now being taken to fit control governors to all two-car units. These governors are connected to the train pipe and through them power is cut off from the main traction circuit until the pressure in the pipe has risen above a predetermined amount.

Books Received

Electricity Undertakings of the World, 1952–53. Sixty-second edition. By Stanley G. Rattee. London: Benn Brothers, Ltd., 154, Fleet Street, E.C.4. Price 30s.

Electrical Measuring Instruments. Second edition. By C. V. Drysdale and A. C. Jolley. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 75s.

The Gantt Chart. By Wallace Clark. Third edition. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 12s. 6d.

Factory Organisation and Management. By N. F. T. Saunders. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 16s.

Analytical Mechanics for Engineers. Fourth edition. By Fred. B. Seely and Newton E. Ensign. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 44s.

The Institute of Metals

ANNUAL GENERAL MEETING

No. I

ON Tuesday, March 24th, the Institute of Metals began its annual general meeting at the Park Lane Hotel, London.

Report of Council

The President, Dr. C. J. Smithells, in moving the adoption of the report, said the membership now exceeded the 4000 mark for the first time. The council believed that there were still a very large number of people who might be members of the Institute, with benefit to themselves and incidentally to the Institute. Probably members of the Institute, if they put their minds to it, could find new members. Great progress had been made with publications. At the beginning of the year, very largely through lack of money, papers were not being published at the rate they were coming in, but the council directed the publication committee, regardless of cost, to catch up with the arrears, and use was made of the Industrial Fund in order to do that. The result was that they had caught up the arrears. The time now taken for papers to be published after being received was four months, which was the minimum time required for the process of publication.

Mr. E. A. Bolton, in presenting the report of the honorary treasurer and moving the adoption of the accounts, said that the excess of expenditure over income had increased from £2406 in the previous year to £6917. The reason for that increase was very largely increased costs of publications and, as had already been mentioned, the campaign to bring the publications up to date. Publications accounted for about 85 per cent of the total expenditure. On the income side, the membership was rising, and hence revenue from that source was also rising. With regard to revenue from advertisements, on expert advice, there was a change in the format of the *Journal*, which gave an opportunity for better advertisements, and the income from that source, as predicted in the advice which was sought, was steadily rising. The excess of expenditure over income had been met by a transfer from the Industrial Donations Fund, and while the income from that source would tend to fall somewhat over the next six years, it was hoped that by the end of that time the budget, with these increasing sources of revenue, might be very nearly balanced.

The secretary then announced the names of members elected to fill vacancies on the council for the year 1953–54, including Professor F. C. Thompson as president.

After a vote of thanks had been passed to those retiring from the council, Dr. Smithells inducted the new president, Professor Thompson, into the chair.

After a vote of thanks had been passed to the retiring president, Professor F. C. Thompson delivered his presidential address.

Awards were then made of medals and prizes for 1953.

The Institute of Metals Medal, in platinum, for 1953, was made (in his unavoidable absence) to Professor George Masing, of the Institut für allgemeine Metallkunde, Universität Göttingen, in recognition of his outstanding contributions in the field of metallography; the Rosenhain Medal for 1953 was awarded to Dr. Charles Eric Ransley, of the research laboratories, the British Aluminium Company, Ltd., Gerrards Cross, in recognition of his outstanding experimental and theoretical work on gas-metal equilibria, and the W. H. A. Robertson Medal for 1952 and a premium of fifty guineas to Mr. John Francis Waight, of the West Midlands Gas Board, for his paper on "Gas Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys," published in the *Journal*, 1951–52, Vol. 80, pages 269–285.

Two Students' Essay Competition Prizes for 1952 were awarded to Mr. R. D. Stacey, of the University of Birmingham, for an essay on "Some Experimental Evidence for Dislocations," and to Mr. G. Thomas, of Cambridge University, for an essay on "Martensitic Transformations in Non-Ferrous Metals and Alloys."

The meeting then adjourned.

At the morning session on Wednesday, March 25th, the discussion of a symposium of papers on "The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys" was begun.

The following papers were introduced by Mr. N. I. Bond-Williams, who acted as rapporteur.

"The Principles of Technical Control in Metallurgical Manufacture," A. R. E. Singer.

"The Control of Quality in the Production of Brass Ingots and Billets," Maurice Cook and C. L. M. Cowley.

"The Control of Quality in Melting and Casting Copper and High-Conductivity Copper-Base Alloys," J. Sykes.

"The Control of Quality in the Casting of Zinc and Zinc Alloy Rolling Slabs and Extrusion Billets," C. W. Roberts and B. Walters.

"The Control of Quality in the Melting and Casting of Aluminium Alloys for Working," R. T. Staples and H. J. Hurst.

"The Control of Quality in Melting and Casting Magnesium Alloys for Hot Working," R. G. Wilkinson and S. B. Hirst.

Discussion

Mr. Christopher Smith (James Booth and Co., Ltd.): It is refreshing in these days, when the world's technical Press is screaming "Productivity," to read a collection of papers given over specifically to control of quality. There are in this country conditions inherent in the economy and markets of a small industrial island, not rich in the non-ferrous sense in natural resources, which prevent us from competing with the gigantic achievements of the American machine, apart from a few notable exceptions. It is therefore important that our accent should be on quality, and in particular on that kind of beauty which is more than skin deep in our products. Dr. Singer has discussed in the early part of his paper the well-known principles of Quality Control (with capital letters), and I feel that he has over-condensed this part of the paper, a little to the confusion of his readers. To some of us standard deviations are still a little mysterious, and I shall listen with interest if anyone is able to advise us in the discussion that the mathematical conceptions involved in quality control of the type indicated have, in fact, been found of value in the variable range of operations involved in the production of non-ferrous semi-manufactures. I doubt whether it is feasible or practicable to apply to a range of manufacturing operations involving the human factor a system which works satisfactorily in a purely mechanical process such as the production of turned parts in a capstan lathe. I feel myself that the cost of assembling all the relevant facts would be prohibitive. Dr. Singer's observations on the various lags which arise in controlling mechanisms are much more to the point, and I imagine that many of us have been vexed by the wastages of time and material which arise on this account. In many processes we are likely to achieve results of a satisfactory nature by depending on the "know how" of our craftsmen. In the field of tool-making for extrusions, for example, the quality of our products largely depends on the deftness and instincts of our toolmakers. Nevertheless, I agree wholeheartedly with Dr. Singer that the proper and most economic method of control is that which is directly relevant to the factor under review, and that this is a challenge and an opportunity for metallurgists.

Most of the problems affecting quality have been delineated in the papers, and the authors tell us elegantly and consistently how to apply control in the foundry. In some of the papers these problems have not yet been solved, and the authors have perforce been led to discuss not so much the control itself as the means of control. Hence the papers have not a stereotyped sameness, as some may have expected, and they indicate in a most interesting manner how the amount of control possible depends on the amount of knowledge available. In a most interesting manner, too, they reveal that with the newer materials much less is known of the metallurgical principles involved.

Dr. Singer, in his discussion of the economic aspect of the subject, says "For any given process, quality of product and cost of product tend to be mutually opposed, so that in practice some compromise solution must be sought." It would seem to me that, in the case of zinc and its alloys, castings of much better quality would result from the application of the semi-continuous methods currently in use in the aluminium alloy foundries to-day. Is there some fundamental reason why these cannot be applied to zinc and its alloys? Certainly in so far as controlled application of directional solidification is concerned, these methods seem to be ideal, and with the pure metal at least, immaculate casting surfaces should be obtainable. Is the reason for the absence of these more refined methods economic? It has not proved so in the aluminium industry, where increased control over the cooling of the ingots has eliminated scrap except with certain difficult alloys, with an accompanying increase in the output per man-hour.

In the last two decades control has become not the responsibility of technical staff, but an integral part of the function of the whole staff. But it is clear that we have not yet reached the ideal state of affairs pictured by Dr. Singer, and the discussion may reveal how near we can expect to get to that ideal in the next two decades. Whatever may be said in criticism of some of the points raised in Dr. Singer's paper, which I regard as an admirable one, there can be no doubt of the truth of his observation to which I have already referred, and which in conclusion I quote: "In spite of the obvious advantages of controlling primary variables, little progress in this direction has been made in the metallurgical industry. This is both a challenge and an opportunity for metallurgists."

Mr. G. L. Bailey (British Non-Ferrous Metals Research Association): The problem with which we are particularly concerned to-day is how to control the variables governing quality. That involves two questions: before you can control them, how do you measure the quality? Secondly, having measured your ingot quality, how do you put it right if it is going wrong? I think that we can largely dismiss the second question to-day, because the information given in the 1949 symposium on melting and casting and what has been added to it now

tells us very largely what to do ; in fact, there is a very useful amount of information on how to put things right if they have gone wrong, but how to measure ingot quality is not so easy to decide. Something has already been said about Dr. Singer's definition and distinction between primary and secondary variables. I should like to take this point up. We can directly control a variable only if we can directly measure it, and I am not quite sure what Dr. Singer means by his primary variables. Dr. Singer uses primary and secondary variables for things which I should not have thought fitted that definition, and I should very much like to have from him some elucidation of what he means in the use of these two terms. My definition would be that a primary variable was one of those variables of ingot quality that one was ultimately setting out to measure in some way or other. We are trying to make an ingot which is of the right composition, an ingot sound and free from shrinkage and gas and cracks and all the other things which generally and collectively cause unsoundness. We want an ingot of good surface and of the right grain size. Of those things, the only one which, it seems to me, we can directly measure and correct as we go along is composition. Staples and Hurst have shown how the direct-reading spectrograph is used in the aluminium foundry, and there is every prospect in the very near future of the same type of instrument, the same instrument suitably modified, being used for the other elements, to be used in the same way in copper and copper alloy foundries ; but to use this instrument regularly it is necessary to have fairly large melts and to be able to hold the melts for a few minutes while checking the composition and putting it right if it is wrong. It is necessary to have a very large output to justify the expense of an instrument which costs something like 30,000 dollars. That, however, is something which you can control as you go along, and it will increasingly come into use for other materials as well as in the aluminium industry. You cannot, however, measure the soundness of an ingot during the casting operation and control it as you go along. The really important point which I read into Dr. Singer's challenge to metallurgists which I think is a very sound one is this. There are three things which can be done. Control of ingot quality during manufacture is possible only to a very limited extent. We can have examination in the second stage, the casting, which should be very rigorous, for pipe and surface irregularities and shrinkage, and by that rigorous examination only pass on what is good. The third control comes in when we have our rolled product and there is something the matter with it, because there is something the matter with the ingot. Dr. Singer's challenge to us is to see whether we cannot bring these processes forward at all, whether we can do something at an earlier stage which we have been in the habit of doing later, and above all whether we can avoid putting material through the subsequent operation if it has something the matter with it. The only hope that I can see at the moment is that greatest attention—even greater than is usually paid—should be given to an examination of ingot quality before the ingot is passed forward for subsequent fabrication. If I were to argue with anything that my friend Mr. Christopher Smith said, it would be with his introductory comments about productivity. He said that it was a pleasant relief to have some papers on quality control instead of all the talk about productivity ; but surely productivity means something more than time and motion study, something more than getting the most out of your workpeople. It means getting the most efficient production operation from beginning to end, and one of the most important steps in getting high productivity is to avoid making material which is no good when you have made it. Quality control, therefore, is one of the most important features of productivity.

Mr. Christopher Smith referred to the importance of craftsmanship, and I agree with him wholeheartedly. How to preserve some of the craftsmanship of the industry and at the same time tie things up so tightly that everything can be controlled is one of the problems which we have to face. I do not know what the answer is.

Mr. E. A. Bolton (Imperial Chemical Industries, Ltd., Metals Division) : There has been some talk already of the control of primary and secondary variables, and I should like to cite one case which gave us a little trouble. We had to manufacture a ternary alloy for electrical resistance purposes, and we started out by assuming that if we made up the alloy to a certain composition we would get the results that we required—that is, a narrow band of variation of electrical resistance. We found that that did not work out in practice, and so we instituted an electrical resistance test. It was in the form of wire at a certain stage through which all the alloy had to pass, and we actually controlled the electric resistance and did it by statistical quality control methods. We worked backwards from that control, as we saw the results begin to swing to the high or low part of our range, by making suitable adjustments at an earlier stage. That worked very well indeed. Several speakers have already referred to control at the early stages, and that is of great importance, because at the casting stage we have spent comparatively little on our product compared with the amount that we are going to spend on it during the subsequent work. I would suggest that we can therefore at that stage afford to spend a great deal more on our inspectorate or our inspection than we can at later stages, so as to ensure that we do not pass forward defective castings and spend much more money on them. I should like to have the opinion of members on what form that inspection should take. Should there be a separate inspectorate as distinct from the actual casting shop control, an inspectorate built up from the technical staff ? Possibly there should be.

I mentioned two nights ago, at our dinner, that I should like to have an instrument which would tell me, as soon as the ingot was in the mould, whether it was a good one or a bad one. Someone suggested that what I really wanted was a horoscope, but I do not like the " horror " in it.

Dr. W. G. Hiscock (Imperial Smelting Corporation, Ltd.) : Whilst I would in no circumstances detract from the excellent work which is in progress in improving quality by better technological practices in manufacture, by research, by better methods of examination or by the use of statistical quality control in inspection, my view is that the first essential is to produce in the manufacturing teams the highest morale possible, with the attendant desire in all concerned to produce the highest possible quality. The importance of control of chemical composition is emphasised in all the papers, and it is pointed out that, where no refining is possible, the quality of the final product is governed by the composition of the raw materials. Evidently, therefore, the scrap used in making up charges requires very careful sorting and identification, and it would be very interesting to know how this is carried out. Cook and Cowley, in their paper on brass, and Sykes, dealing with high-conductivity copper alloys, have dealt with the subject to some extent, but little information was given on the procedure adopted in the aluminium and magnesium industries. Is it normal practice to sort the various alloys into types by eye and then melt and analyse the ingots, or are methods available whereby the various alloys can be identified with sufficient accuracy to permit the inclusion of a proportion of scrap in a charge for the direct production of rolling slabs, and so on ?

Mr. F. Kasz (The British Aluminium Company, Ltd.): There are two aims in any casting shop. The first is the production of a homogeneous liquid of the required composition, and in " composition " I include all impurities, whether solid, liquid, gaseous or whatever they may be. Having transferred the liquid without change to a container, the second aim is to effect a heat exchange in that container or mould so that the components are distributed in the resulting solid in the required manner.

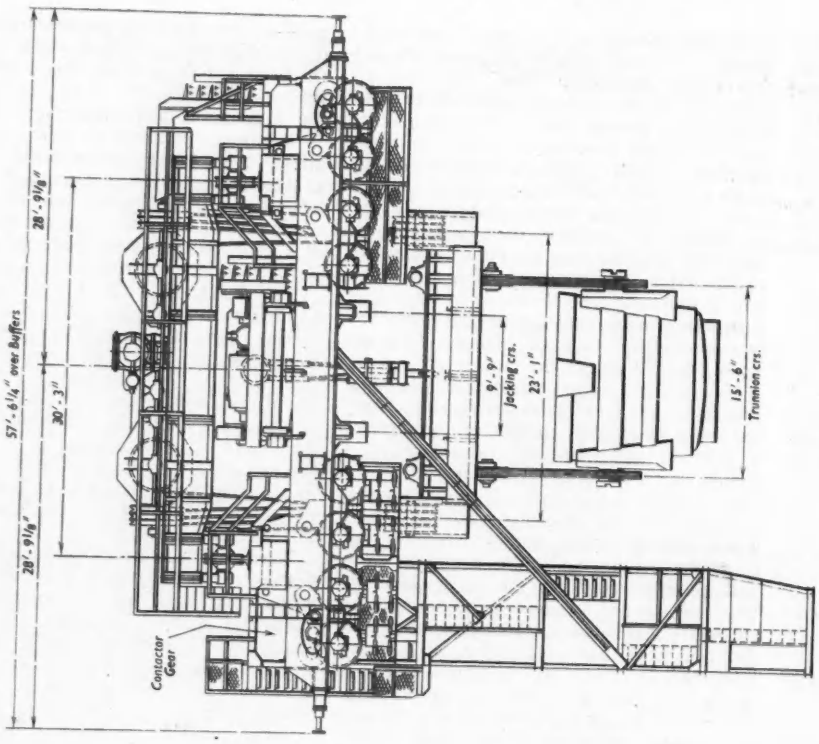
Turning first to composition, an impressive feature of all the papers is the fine limits to which the impurities are controlled on an industrial scale. The light alloys are no exception. The observation by Staples and Hurst that scrap and secondary ingot charges give more consistent results than virgin ingot charges tends to suggest, however, that such control must be extended. It would be interesting to know from them in what respect the material behaves more consistently. It would also be interesting to know just how far they have pushed their analytical inquiry. If there is a rule, it must be observable by compositional differences. Such an experience is not entirely parallel to our own ; we find that quite a wide variety of charges can be made to yield equally consistent results, given appropriate treatment. The authors ask whether the alkali content should be controlled. It is not a question of whether the alkali metal content should be controlled ; it must be controlled and is, in fact, controlled in any up-to-date works.

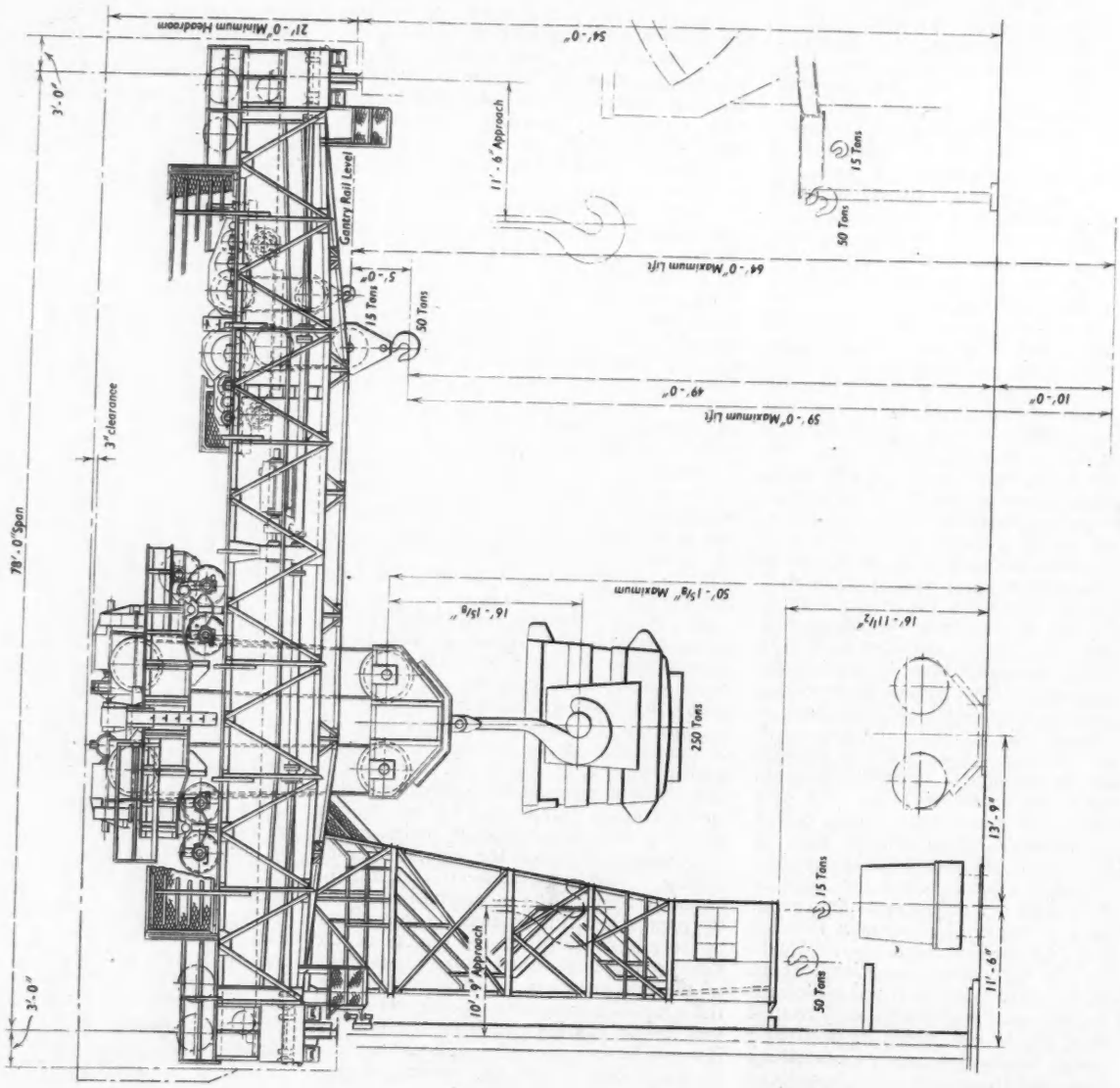
The authors rightly draw attention to oxide inclusions. There can be no disagreement with the view that oxide inclusions in light alloy blocks can be disastrous, but I should like to ask whether the authors can give us further information about some of these finer divided forms of oxide. Have they evidence about this, or are they being highly speculative ? We cannot parallel the experience of Wilkinson and Hirst with their magnesium alloys, where they put a distributor to trap the oxide in the block. I should like to ask them whether that really works ? It is obvious that the authors are very well aware of the dangers of oxide, and I would ask them whether they do not consider it very unsound practice to tap from the bottom of the furnace hearth ? Any furnace hearth can be thick with deposits after quite short campaigns.

It is a little surprising, in view of the admitted importance of temperature, that there is no mention in the papers of thermostatic control, which is commonly practised in the light alloy industry. It is true that the restrictions of former years on different types of furnace for melting aluminium have disappeared with growing knowledge. Equally satisfactory quality can now be produced from a wide variety of furnaces. I wonder also, however, whether the overall melting loss of Staples and Hurst of 2·5 per cent is not about twice as high as it should be. On this question of furnaces, I should welcome any guidance which anyone can give me on the real value of the induction furnace.

(*To be continued*)

250-TON STEELWORKS' LADLE CRANE





Steelworks Ladle Cranes

Two cranes of 250 tons capacity for handling the casting ladles and two cranes of 125 tons capacity for hot metal charging purposes have been designed, constructed and installed in the melting shop at the new steel works of John Summers and Sons, Ltd., by the Wellman Smith Owen Engineering Corporation, Ltd. These cranes, are of heavy construction for continuous service in steel works and their design was evolved as a result of close co-operation between the manufacturers and the users.

FOUR ladle cranes have been designed and built by the Wellman Smith Owen Engineering Corporation, Ltd., to serve the eight 150 tons capacity open-hearth-fired furnaces in the melting shop at the new Shotton steel works of John Summers and Sons, Ltd. Two of these cranes have a lifting capacity of 250 tons and are used for handling the casting ladles and the other two, each with a capacity of 125 tons, are used for hot metal charging purposes. The heavy construction of these cranes to suit them for continuous duty in the steelworks can be seen from the photographs we reproduce and the drawing of the 250-ton crane on page 504.

The two large ladle cranes are designed to lift a load of 250 tons—the maximum combined weight of ladle and molten metal—by means of a ladle beam arranged for four-point suspension from the main trolley. The two ladle hooks on the beam are set at 15ft 6in centres. An auxiliary trolley on the crane is provided with two independently operated hoisting motions, one of 50 tons capacity, which is required primarily for tilting the ladles, and one of 15 tons capacity for general service. In the following table we give the operating speeds and motors for the various motions of the crane.

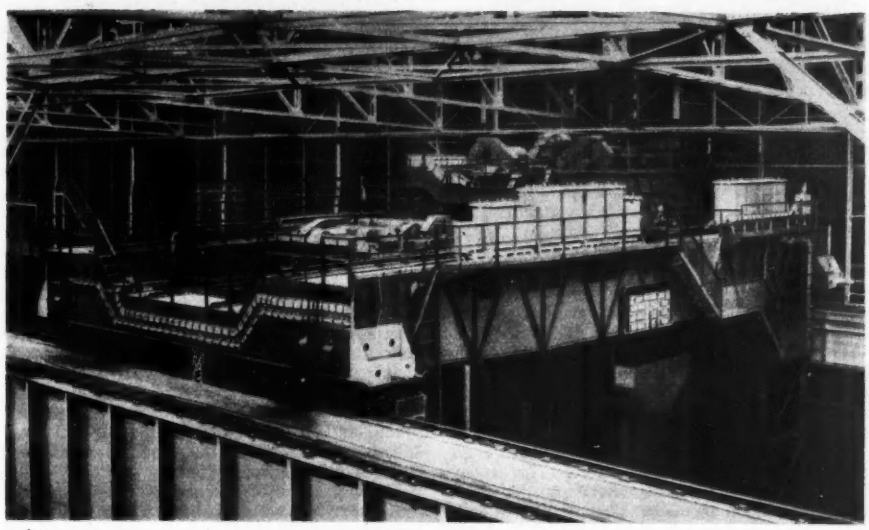
Table of Operating Speeds and Motors
250-ton Crane

	Speeds		Motors	
	Tons	Ft. per min.	H.p.	R.p.m.
Main hoist	250	9	Two 125	605
Main cross traverse	250	75	70	580
Auxiliary hoist	50	30	125	605
Auxiliary hoist	15	50	70	580
Auxiliary cross traverse ...	50	125	20	590
Long travel	250	200	Two 100	650

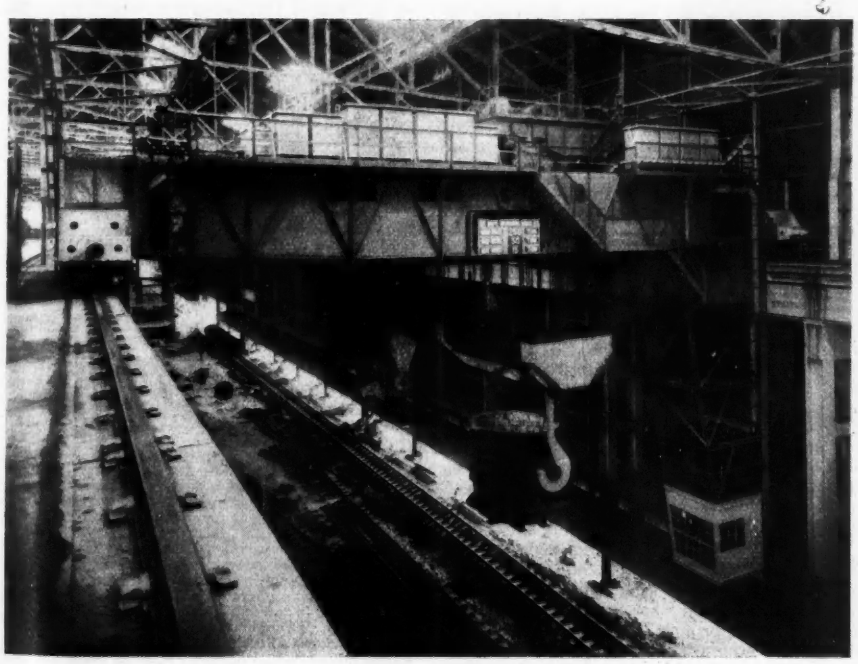
One of the 250-ton cranes installed in the casting bay of the new melting shop is illustrated on this page. These cranes carry the ladles when receiving molten steel from the furnaces and during the teeming of the steel into ingot moulds. The cranes are of four-girder design in which the main trolley runs on the two main girders forming the bridge of the crane. Each of these girders has an outrigger girder with a full-length platform both sides of the crane, and the auxiliary trolley is also provided with its own independent girders, together with platforms alongside, over the full span.

The crane span is 78ft from centre to centre of the gantry track rails, the end clearance from the rail centre line to the face of the building columns at each side of the shop being 3ft. The gantry rail is 54ft above the shop floor level and the headroom clearance from the rail to the underside of the roof members is 21ft. The minimum approach of the main hooks to the centre line of the gantry girders at the furnace side is 11ft 6in and at the opposite side 10ft 9in.

The double web plate main bridge girders, which carry the main trolley, are laterally braced to the outrigger girder by horizontal and diaphragm bracings which form a lattice box construction for carrying the platforms and long travel motors and driving gear. Double web plate design auxiliary trolley girders are also used. Ready access is provided by the platforms alongside each span girder to each trolley and to the rigid tee-bar cross conductors which carry current to the motors on the trolleys. These conductors are mounted above platform level and set behind wire mesh guards.



Main and Auxiliary Trolleys of 250-Ton Crane



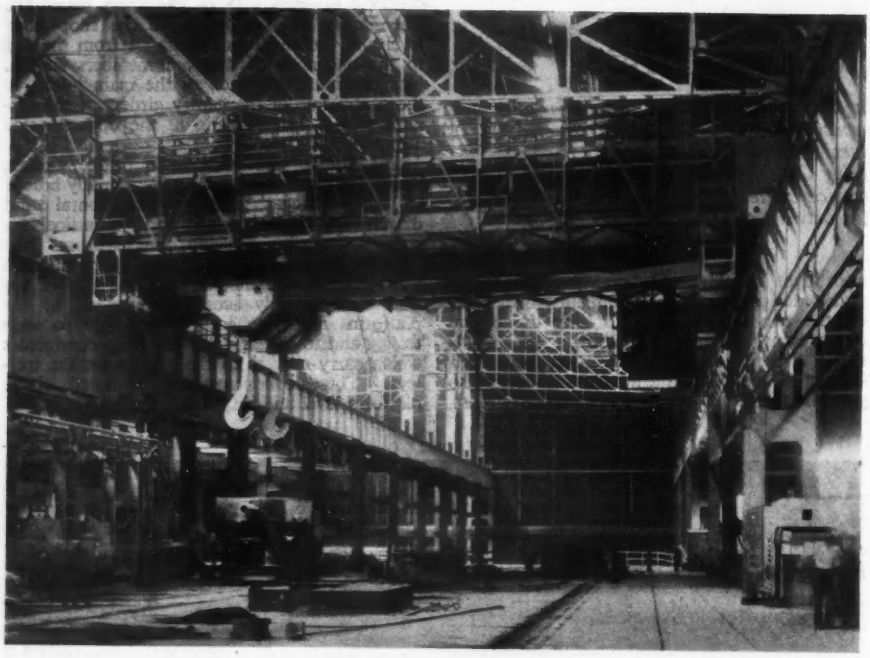
250-Ton Ladle Crane in Casting Bay

Large platforms are provided on the trolleys themselves and special platforms giving access to the longitudinal travel wheels and axle bearings are arranged under the girders at each end of the crane. The crane cab has five decks and the lower compartment for the driver, which houses master controllers and auxiliary switch gear, is suitably insulated and sealed for the installation of air conditioning equipment at a future date.

The cranes are carried on sixteen 3ft 6in diameter steel-tyred travelling wheels, the four wheels at each corner of a crane being disposed symmetrically about the abutment of the main trolley girders. The wheels are mounted on live axles running in bronze bearings and, as can be seen in an illustration on page 506, they are arranged in pairs in compensating bogies. The compensation between each pair of bogies is effected by massive rocker levers so arranged that on jacking-up the crane, both bogies can be run out without removing the heavy pins forming the main pivots of the compensating gear. One of the wheels of each of the four outer bogies is driven through an end gear reduction on the bogie itself from a 100 h.p. motor and reduction gear unit situated at the centre of the span on each side of the crane.

The main trolley is carried on eight 3ft diameter steel-tyred cross traverse wheels mounted in two-wheel compensating bogies. Two of the bogie wheels are driven from the 70 h.p. cross traverse motor through enclosed spur gearing, the design of the drive being substantially similar to that of the long travel motion.

The main hoisting gear is driven by two 125 h.p. motors driving through interconnected first and second motion reduction gears to four 4ft diameter steel hoisting drums arranged in pairs with right and left-hand grooving for coiling the hoisting ropes. The load is carried on thirty-two parts of rope, return sheaves being rigidly mounted on the trolley, and at the stand-



125-Ton Hot Metal Ladle Crane

ing ends of the ropes provision is made for independent adjustment to take up any inequalities in stretch.

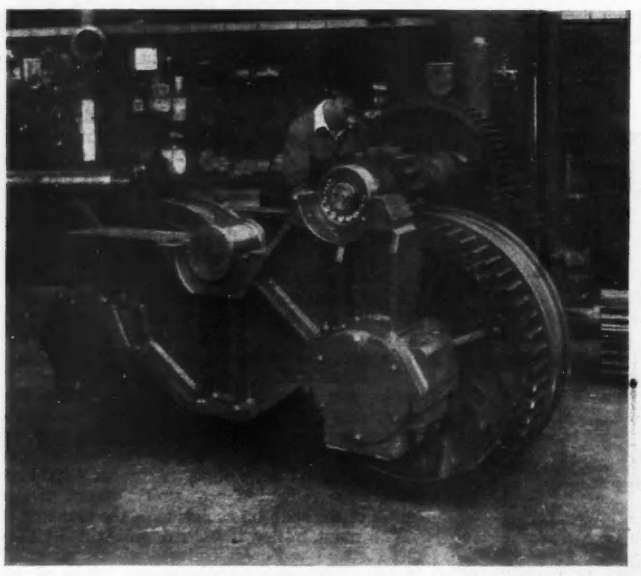
On the auxiliary trolley there are two hoisting motions, one of 50 tons and one of 15 tons capacity, each independently operated by an electric motor driving through enclosed spur reduction gearing and having steel hoisting drums of 3ft 1½in and 2ft 6in diameter arranged for eight and four falls of rope, respectively. This trolley is carried on four 2ft diameter runners, which are mounted on through axles running in self-lubricating bronze bearings.

A complete crane weighs approximately 500 tons without load and the maximum rolling load when fully laden is thus 750 tons. Under conditions of maximum loading and with the main trolley at its closest approach to one side of the shop, the total load on the gantry from one crane amounts to 542 tons, the maximum individual wheel loads being 68½ tons at the driver's cab end of the crane, and 67 tons on each of the other four wheels. One of the two 125-ton hot metal ladle cranes used for charging hot metal into the furnaces is also illustrated on this page.

In these cranes the combined weight of the ladle and molten metal is suspended from the main trolley in a manner similar to the 250-ton cranes, with four-point suspension of the ladle beam. On this beam the two ladle hooks are spaced at 13ft 4in centres to suit the hot metal ladles. The auxiliary trolley used for tilting the ladles is of 25 tons capacity.

The cranes are of design similar to the larger four-girder units described above and the operating speeds and motors are given in an accompanying table.

Each crane has a span of 78ft and the end space is 3ft from the centre of rail to the face of building columns, the gantry rail level being 60ft above floor level with 21ft 4in headroom. The main hook approach is 7ft 3in at the furnace side and 8ft at the opposite side of the shop. These cranes have a girder construction substantially similar to that of the 250-ton cranes. They have a short cab, which is situated at a comparatively high level to give good visibility when pouring.



Main Trolley Two Wheel Bogie Assembly

The travelling gear is driven by a single 125 h.p. motor through reduction gear situated at the centre of the span on one side of the crane opposite the cab. Drive is transmitted to two of the eight 3ft 6in diameter steel-tyred travelling wheels, which are mounted in pairs in compensating bogies. One bogie is situated under each of the main trolley girder abutments.

The main crane trolley is carried on four 3ft diameter steel-tyred cross traverse wheels mounted on live axles running in bronze lined bearings. Its main hoist gear is driven by a 125 h.p. motor through enclosed gears, of which the second motion train is divided to drive two 3ft 6in diameter steel hoisting drums for coiling the sixteen falls of rope. An auxiliary trolley hoisting motion of 25 tons capacity is carried on eight falls of rope, the steel hoisting drum being 2ft 11in diameter. This trolley runs on 1ft 9in diameter steel-tyred cross traverse wheels with through axles mounted in bronze bearings.

The unladen weight of the 125-ton crane is approximately 260 tons or 385 tons when carrying full load, and the maximum individual wheel loads on the gantry is approximately 71 tons.

All the electrical equipment of these cranes operates on a 220–230V d.c. supply. The motors used are all of Laurence Scott "Super" mill design, series wound, one-hour rated, their horsepower and running speeds being as indicated in the tables we give of the operating speeds. All motions are controlled by contactor control gear with the exception of the auxiliary cross traverse motions, which have heavy service steelworks design drum controllers, giving plain series control in each direction except on the lowering side of the hoisting motions, which are arranged for potentiometer control with dynamic braking. Protective devices for all motor circuits are arranged in a separate protective panel.

Table of Operating Speeds and Motors of 125-ton Cranes

	Speeds		Motors	
	Tons	Ft. per min.	H.p.	R.p.m.
Main hoist	125	10	125	605
Main cross traverse	125	75	30	590
Auxiliary hoist	25	30	70	580
Auxiliary cross traverse ...	25	125	15	660
Long travel	125	225	125	605

An Igranic electro-mechanical brake is fitted to the motor extension shaft of each drive and an Igranic Palmer overwinding switch with a dynamic braking stop is provided on the hoisting motions.

British Refrigeration Association Annual Luncheon

THE British Refrigeration Association held its ninth annual luncheon on March 20th in London; Mr. R. H. Hemmings, the chairman of council, presided. Proposing the toast of "The British Refrigeration Association," Mr. E. Hartley Leather, M.P., emphasised the seriousness of the problem of purchase tax as it affected the refrigeration industry. He said that, apart from the essential role played by refrigeration in modern industry, it was closely linked with the standard of living so that purchase tax was a handicap in all directions. He regretted the findings of the Douglas Committee and the Hutton Committee, which, he claimed, would act as a brake upon progressive industries. In his reply, Mr. E. G. Batt, the director and secretary of the association, said that for the first time production returns had fallen, the total for 1952 being £23,500,000, a reduction of £3,500,000 compared with 1951. However, he thought that the results reflected a great effort on the part of the industry, especially considering that the Australian market, representing about 17 per cent of the total production, had been practically lost. With regard to the home market, Mr. Batt attributed the 50 per cent drop in refrigerator sales to the crippling rate of purchase tax which, he said, prevented the development of new and improved products for export. Mr. Batt also commented on the findings of the Hutton Committee on "Tax Paid Stocks," which had occasioned considerable dismay throughout the industry.

MAUDSLAY SCHOLARSHIP.—The Junior Institution of Engineers announces that, through the generosity of the Maudslay Society, it is able to offer a Maudslay scholarship to young engineers to assist them in their technical education and practical training. The value of the scholarship is £150 a year. A candidate for it must not have passed his twenty-sixth birthday and must be an engineer or training to be an engineer wholly or mainly interested in mechanical engineering. At the time of application a candidate need not be a member of the Junior Institution, though he must be eligible for membership. In suitable cases the scholarship may be renewable for a further period of one or two years. Applications for the scholarship must be made not later than July 31, 1953, to the Secretary of the Junior Institution of Engineers, 39, Victoria Street, London, S.W.1.

Some Aspects of High Performance Jet Aircraft

By SQUADRON-LEADER W. A. WATERTON, G.M., A.F.C.*

In this abstract of a paper read before the Derby Branch of the Royal Aeronautical Society, on March 12th, a test pilot comments frankly on several pertinent and some controversial issues relating to the design, performance and manufacture of high-speed military aircraft, particularly where these factors influence the handling characteristics.

Most sections of the aircraft industry with something to make, something to describe or something to sell will doubtless find much to take issue with in what is about to be said. No apologies are forthcoming, however, since it is proposed to speak about, and of, aircraft as found and experienced by pilots and operators.

Along with Lease-Lend the North American idea of high pressure salesmanship appears to have permeated British aeronautical matters together with all the superlatives ending in "er." Of all mankind's ingenious devices probably none are more full of compromises than aeroplanes, therefore adjectives describing one or more of their aspects may be noteworthy but when they tend to overflow a sceptical eyebrow may well be raised.

Whereas aviation a quarter of a century ago was in the immediate hands of enthusiastic builders, pilots and operators, the position has somewhat altered in recent years, to the extent that aeroplanes and their operation are first and foremost very large, and not unprofitable, commercial enterprises. Air crew are, therefore, at best necessary but perhaps undesirable adjuncts to the whole scheme of aviation. Since, however, they have the advantage of electronics in adaptability, flexibility, serviceability and, initially at least, easy production, piloted aircraft may yet be with us for a day or two. Herewith then, for consideration, are some observations and practical experiences on some aspects of high performance jet aircraft.

Control/Stability

The following examples are merely quoted to show that figures and theory do not always tell the whole story. The most economic and efficient aeroplane is one which has sufficient performance strength, control and equipment to do the job required of it, be it dropping a bomb, shooting down an enemy, delivering a load, taking photographs or training pilots. It therefore becomes a compromise of the various factors which go together to provide the correct combination. This is a most important concept and one which is often forgotten, too much stress being paid to the unimportant or to one particular aspect to the exclusion of others no less important.

The early "Mustang I" with Allison engine and the "Spitfire 14" will always stand out in memory as two examples of opposites. The first, one of the most aerodynamically perfect fighters with beautiful controls and handling qualities, was yet unfit for serious fighter operations by virtue of its lack of performance and general "gutlessness" in the climb and at altitude. The "Spitfire 14," on the other hand, was a vile aeroplane from the handling point of view, yet it had performance in climb, in altitude, in turning and in acceleration and because of these points it was a successful fighter, although it threw a lot of responsibility for success on the pilot. Had it combined the stability and controls of the "Mustang," how much easier would have been the pilot's job. When the "Mustang" was given performance with the fitting of the "Merlin" engine what a superb fighter it became. We in Britain from the days of the "Camel" have thrown a lot on the pilot to get the best out of our aeroplanes and, unfortunately, in so doing have made the job unnecessarily hard and severely handicapped all but the above average pilots. In the past if our aeroplanes have had bad performance we have tended to "make do" with handling characteristics. Unfortunately there is some evidence to suggest that this state of affairs may still be continuing.

In addition to performance, which is an absolute essential, stability and control under all conditions of flight are essential to the pilot carrying out his job—to this must be added psychological necessities of comfort, vision and security. With the enormous increases of speed and altitude, coupled with that often overlooked but most vital factor—rate of change of conditions—the problems have increased enormously.

The stretching out of the speed, Mach number and altitude ranges, have played such havoc with control hinge movements, stability and damping that old proven methods are no longer adequate and performance has once again outpaced ability to control it to the necessary degree of precision to get the best out of the aircraft.

Stability.—A deterioration of static and dynamic longitudinal stability occurs with increasing altitude; low air speed (A.S.I.)† and high incidences near the stall (swept wings in particular show these tendencies) and greater variation of engine power.

Variations in stability may further result from aeroelastic distortion, up float and down float of controls, and compressibility effects due to local breakdown of air flow or turbulent air condition.

A 100km closed circuit record attempt in a "Meteor" Mk. 4 against better judgment in a 60 knot gale, provided a most convincing example of these effects. At the 510 to 520 knot speed at which the aircraft was flying, at low altitude in gusty conditions, complete reversals of stick forces, from heavy pull to heavy push, were encountered. At these speeds the aircraft was in the range where its centre of pressure was subject to rapid shifts for small changes in speed. In the end, with a following wind, the aircraft put its nose down and elevator effectiveness deteriorated markedly as though the aircraft were flying at around 0·85 True Mach number (T.M.N.) instead of near 0·8. It would appear that with the tail wind the aircraft, although itself only flying at about 0·8 T.M.N., was covering the ground at round about the 0·85 mark. Should the speed of the surrounding air suddenly drop, a sudden rise in aircraft Mach number could occur and in this case undoubtedly did. Oblique air flow resulting from air pockets or gusts can also give rise to changes in Mach number. It would be interesting to know how many high-speed aircraft through this phenomenon have hit the ground through loss of control or have broken up through instability.

Damping.—Unfortunately, with the low dynamic pressures prevailing at altitude, damping, like stability, falls off seriously and constitutes a real problem to the pilot not only in carrying out a specific task but in the great concentration required to maintain accurate straight and level flight.

Control.—Not only are the basic flight characteristics of high performance jet aircraft possessed of more variables, but likewise so is the behaviour of controls over the increased speed, Mach number and altitude ranges. These effects are listed below :—

(*a*) Rises of hinge moments, with A.S.I. ranges, of 7 to 1 or over and Mach number effects in the transonic and sonic regions.

(*b*) Lack of self-centring coupled with poor and unequal responses over the speed, Mach number and altitude ranges, as well as the angular range of control movements result in lack of sensitivity, crispness of feel and effectiveness at low speeds, and over-sensitivity at high A.S.I. with excessive stick forces.

(*c*) Changes of hinge moment characteristics with Mach number, especially in the transonic range where local breakdowns occur and give rise to buffeting and to stick forces beyond the pilot's strength to control easily.

(*d*) Lack of effectiveness at supersonic speeds results in poor control.

(*e*) Deterioration of damping at high A.S.I.s and Mach numbers gives rise to undulating flight and even flutter in many cases.

All these variables are tied up with those of the medium through which the aircraft travels, and can be related to A.S.I., Mach number and altitude, or combinations of these three. So numerous are these that the demands of stability and control over the performance range of modern aircraft have become tremendous and for the moment at least the poor aerodynamicists, in conjunction with designers, have been able only to supply, at best, partial solutions towards the ideal which pilots would like and which would enable the aircraft to achieve its maximum efficiency.

Boosted and power controls now appear to be the order of the day in British aircraft, some ten years at least after being fitted as standard equipment in the Lockheed "P38" and at least seven years after the Lockheed "F80" and Republic "P84" were fitted with full power ailerons. Even the latest generation of high performance British fighter aircraft have been forced to full power after futile attempts to get by on spring tabs and moderate power boost. Further complications have been induced by severe flutter tendencies encountered on some new aircraft that one cannot but feel that there is something amiss basically in our assumptions. Stretch of circuits and float of controls have further added to the twin problems of stability and control. Despite its many complications and disadvantages full irreversible power on control surfaces appears to be the only practicable answer at present.

The great danger of brute force, however, is that it can cloak a great deal of ignorance, but for the moment at least let us accept the brute force as a means to an end and put up with the ignorance. This should not, however, be taken as justification to sit back without further action on aerodynamic lines in search of perhaps cheaper and less complicated solutions. The finest and highest performance in the world is of no avail unless it can be placed easily, quickly, precisely and accurately in position to carry out its appointed job or role.

After all, the "MIG.15" appears to be supersonic without the benefit of power controls, and so was the Bell "XS-1." All of which brings us to the problems of supersonic flight.

Supersonic Flight

In the first instance supersonic flight has been of a duration measurable in seconds during rapid dives from high altitudes at very steep angles, usually well exceeding 45 deg. from the horizontal. There have been exceptions in the cases of chemically powered research aircraft but such flights have been at extreme altitudes and of very short duration by virtue of the thirst of the rocket motors. Because of the terrific rise in drag at high subsonic speeds it would appear to be a day or two yet before sustained, or even significant increases in the duration of supersonic flight will be attained. The present engines, excellent though they be, still require help from Sir Isaac Newton to overcome high transonic drag. The more powerful engines undoubtedly on the way will help, but any rise in thrust immediately foreseeable is hardly like to approach that "urge" gained from the earth's attraction when the weight of a medium aircraft is added to the engine power by putting the nose down—well down—into a dive.

Amelioration and lessening of dive angle, however, can be expected with more powerful engines, particularly if coupled with clearer, sleeker aerodynamic shapes. By cramming multiple engines in small, heavily laden airframes of limited fuel capacity, we may well achieve level supersonic flight by accepting high landing speeds, lack of manœuvrability, except at top speed, and very short range and endurance.

Together with the great increase in drag, transonic and supersonic flight are posed further problems by our twins, stability and control, both of which manifest themselves somewhat in the supersonic and more particularly in the transonic range.

Experience so far with a variety of fighter aircraft of varying weight and aerodynamic form has confirmed the following general pattern of behaviour :—

In the transonic range changes in longitudinal stability may take the form of (*a*) nose up or nose down changes of trim and porpoising and longitudinal pitching.

(*b*) Changes of lateral stability manifest by alternate wing dropping through 10 deg. to

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† Conversely large increases in stability tend to occur with very high A.S.I.s.

20 deg. or more, or a single wing dropping severely.

(*c*) Changes in directional stability taking the form of directional oscillations with poor or no damping (snaking); sudden directional jerking or kicking over of the rudder.

(*d*) Severe buffeting of some main part of the structure or of a control itself.

(*e*) A loss of control effectiveness so that continued movement of a control produces no effect and may give the impression of a reversal since the aircraft may continue to deviate (e.g. stick further back, nose continuing to drop is a common experience).

In the sonic and supersonic range the following are noted: (*a*) cessation of buffeting and a smoothing out of the flight; (*b*) stability becoming more normal; (*c*) controls becoming more normal in so far as they centralise and do produce normal effects; (*d*) heavying of controls with a great loss of effectiveness manifesting itself in very low rates of roll and a lack of elevator power. So deficient has been this latter control that recovery from the dive is invariably made on the trimming tailplane or else, after a return to subsonic speed and elevator effectiveness.

Summary.—Trailing edge controls do not appear to be the answer to either transonic or supersonic flight conditions, deteriorating to such an extent that control of the aeroplane is insufficient to manœuvre it with requisite precision or rapidity. There is, however, a certain amount of evidence that trailing edge thickness can be of influence under these conditions but such research or theories have not, as yet, provided practical answers. Dive recovery on British and American aircraft has been on the moving tailplane—one aircraft has even resorted to locking its elevators to the tailplane and flying solely on trim in order to relieve buffeting and so achieve and recover from supersonic flight. It is no accident that the "F.86" has gone to the so-called "flying tailplane," where the pilot's stick moves the tailplane as well as the elevators, nor is it remarkable that this is the aeroplane over which it is considered the pilot has control during such conditions, to the point of being really practical.

Heaviness of controls—buffeting and variation of hinge moments can adversely affect transonic and supersonic flight to the extent of preventing the latter. In these cases high power boost ratios or, preferably, irreversible power controls, provide an answer in giving the pilot sufficient power to correct manually control and stability upsets, such as wing dropping—aileron buffeting and porpoising. The worst region appears to be around 0·93 to 0·96 or 0·97 indicated Mach number (I.M.N.) and if control can be maintained over this range—supersonic flight is usually easily possible.

It is surprising the effects small changes have on transonic flight conditions and how a small aerodynamic clean-up or modification can make an otherwise uncontrollable and dangerous aircraft capable of transonic and supersonic flight when previously it ran outside its pilot's capabilities or sensibilities in the 0·85 to 0·95 region.

Design and Manufacturing Tolerances

Designers and aerodynamicists have publicly deplored the lack of full-scale information in respect of new aircraft and, to be sure, aircraft do not in all cases parallel their model tests in wind tunnels. This is usually put down to scale effect, a theory which cannot be relied upon to account for all that happens.

Although tunnel models are made of some hard, dense, smoothly polished wood, such as mahogany, their full-scale counterparts come into being with seams, orifices and "an epidermis," which is often varying in its profile due to manufacturing techniques and tolerances, as well as distortion in flight due to panting and "oilcanning." It is therefore no wonder that results do not agree.

Both in design and manufacture small irregularities are often accepted as either a normal condition unworthy of either further detail design and refinement, or else beyond easy manufacturing capabilities. It is submitted that small leaks, surface irregularities and lack of cleanliness in detail can cause detrimental effects in handling and impose performance limitations out of all proportion to their size. In support of these remarks the following examples of first-hand experience are offered.

(*a*) A large twin-engined heavy fighter having droop snoots fitted to the leading edges of its wing to flatten out the sharp peak in the lift curve at stalling incidence, predicted from tunnel results, failed to show this expected characteristic but gave up to 30 knots progressive stall warning through increasing lateral instability and buffeting. By cleaning up nacelle/wing root fillets and taping over the inboard and outboard (2ft from nacelle and tip) vertical $\frac{1}{8}$in slots in the leading edge of the wing between the structure proper and the droop snoots, all lateral instability and buffeting disappeared completely, the aircraft showing a very sudden stall and sharp wing drop at the same original ultimate stalling speed, but minus the warning. The requisite 8 to 12 knots stall warning was then easily adjusted by the fitment of small spoilers at the wing roots. When the aeroplane was made to resemble more closely the tunnel model it did in fact approximate its tunnel results, having initially shown vastly different characteristics.

It is of interest to note that this improvement also allowed an approximate 0·03 increase in Mach number and that further small refinement, plus increasing control boost ratios to enable the pilot to hold a wing up, endowed the aircraft with supersonic capabilities which have, in fact, been realised.

On the same aircraft, wing tip tanks resulted in a considerable drop in aileron effectiveness. Tufting and photography showed a breakdown over the outboard one-third of the aileron which was put right by a small change in fairing between tank and wing.

(*b*) A well-known aircraft at over 430 knots A.S.I. suddenly changed its rudder trim and in certain cases started appreciable directional snaking. Pilots' observations showed engine intake lips and nacelle intake skin to be sucking in, coincident with this phenomenon. A few pressure venting holes in the right places resulted in a cure for this particular skin deformation.

(*c*) On "Meteor 7s" a deterioration in directional characteristics can result from a loose or badly fitting canopy sealing strip along the starboard hinge line.

(*d*) A fighter aircraft which exhibited heavy stick forces and uncontrollable aileron buffeting and reversals in the lower 0·9 Mach number range was improved by a small local clean up in front of one aileron, to the extent that the pilot could control relatively easily the aeroplane laterally in the transonic range and achieve supersonic speed, which previously could not be reached.

(*e*) A new canopy fitted to an old-established aircraft gave rise to noticeable vibration of rudder and elevators, as well as considerable cockpit noise and discomfort. Despite the protests that a gap between canopy valance and fuselage could not be bettered in production, it was sealed with felt strips experimentally with the result that cockpit noise and discomfort almost entirely disappeared and so did all the elevator and rudder vibration.

(*f*) An accurate and constant adjustment to control surface shrouds of a small fraction of an inch made quite decent controls out of those previously showing extremely adverse characteristics.

(*g*) Stalling characteristics of certain aircraft have varied from good to vile with changes in filler and painting of leading edges of mainplanes; so have Mach number characteristics. One well-known aircraft has had its stalling characteristics put right and was made acceptable by the application of filler on the mainplane and leading edge forward of the ailerons.

(*h*) Jet aircraft have been found to have dropped as much as 80 knots from their original top speed from "bashed cowlings" and leading edges resulting from careless handling and maintenance by clumsy ground crews.

Countless other examples of the effects on handling and performance caused by small irregularities and lack of attention to detail design, manufacturing technique and tolerances, as well as careless maintenance, could be quoted but it is hoped that the foregoing may show how important such items are. Unfortunately, there is some evidence that the British industry in general does not take seriously enough the fact that small details can have such adverse effects out of all proportion to their size.

If a study is made of photographs of many aircraft, visual evidence is often to be had of wrinkling and panting of skins—a most pertinent factor in good control and even stability.

From the foregoing one wonders whether or not due and sufficient thought have been given to the radical alteration of methods of design and construction, which basically have changed but little in the past fifteen years. Would not heavier skins and less light internal tin-mongery provide more accurate surfaces, without panting and distortion due to air loads or suctions as well as conferring greater stiffness as a deterrent to aeroelastic distortion? At the same time would they not provide a firm foundation for power control jacks to push against and additionally, allow more internal space for fuel and equipment, particularly inside wings?

Performance/Aircraft Configurations

There has been much talk of the superiority of the swept wing over the straight wing, the delta wing over the lot and even, later still, the straight wing coming into its own again. To say that one is better than the other without qualifications is deceptive, to say the least. Although one hears at great length the virtue of one configuration or another, the defects of that particular layout are no more mentioned than are the advantages of the rival. It must be patently clear that each has something to offer and each has certain disadvantages and only that configuration offering the best possible combination for the role of the aircraft can truly be said to be most advantageous.

Power Loading.—One very prevalent school of thought maintains that given sufficient power, wing loading becomes relatively immaterial, a highly powered, heavy aircraft being able to hold its own with a more lightly loaded adversary. Given equal lift coefficient characteristics this is not so, since for a given A.S.I. the more lightly laden aircraft will be capable of attaining more g or, conversely, can achieve a given g at a lower speed and so out-turn the machine with the heavier wing loading. There is an optimum power required to overcome increased drag and here again the more lightly loaded wing with its reduced incidence bestows an advantage.

Superiority in tightness of turns was claimed of the swept plank wing over the straight wing and this was partially true in so far as it showed superior lift characteristics at high Mach numbers, whereas those of the straight wing were falling off. In most cases, however, for structural reasons, this advantage was largely thrown away by the higher wing loadings employed by swept wing aircraft, since at lower speeds and Mach numbers the lightly loaded straight wing generated lift which the other could do only at higher forward speeds. Thus could a straight winged aeroplane possess better turning capabilities and thus is shown up the benefits of a light wing loading.

Wing Loading.—This must always be a factor in turning and climbing capabilities particularly at high altitudes. Generation of lift at a given speed will always provide an indication of turning capabilities and the aircraft which can achieve, say, a 3g turn at 0·8 I.M.N., will handily out-turn one which must do a 0·9 I.M.N. to achieve a similar g value. Provided that lift coefficient does not fall off with Mach number and sufficient power is available to overcome drag, the low wing loading should show up favourably every time.

If a low wing loading can be coupled with adequate power loading, plus sufficient strength, it not only scores in this important regard but provides the following in addition:—

(*a*) A lower stalling speed.

(*b*) A higher ceiling.

(*c*) A useful low speed range for advantageous search and handling qualities under instrument, night and bad weather conditions.

(*d*) Lower approach, landing and take-off speeds, allowing the use of smaller aerodromes or a bigger factor of safety on present ones.

(*e*) A greater range of usable and controllable

speed, particularly at altitude where, with roughly all modern aircraft showing compressibility manifestations at 0·93 to 0·96 I.M.N., the lowering of the stalling speed by 20 to 30 knots gives the pilot comfortable flying, control and manœuvrability at speeds at which a more heavily laden aircraft is on a "knife edge," or falling out of the sky.

Aspect Ratio and Span Loading.—The advantages of high aspect ratio and low span loading have long been recognised as factors determining low induced drag and aerodynamic efficiency, making for excellent altitude performance. Perhaps no better example of these features can be found than in sailplanes, yet such a form could not be incorporated in military or high performance aircraft to operate over the requisite speed, Mach number and altitude ranges by virtue of structural requirements.

Low aspect ratio and high span loadings, it is true, do militate against getting the best out of an aircraft, but much can be recovered by keeping wing loadings low and so keeping down incidence, particularly at altitude.

Planforms.—The straight plank wing provides good control, stability and structural possibilities, possibly because so much research has been devoted to it and so much experience has been gained over many years. In addition, if made thin enough it can offer good transonic and supersonic possibilities, but only at the expense of loss of space and severe structural problems and an increase in wing loading.

The swept plank wing can offer a notable improvement over the straight wing of equal thickness in drag reduction at high speed and Mach numbers and in lift coefficient at high Mach number. It can provide reasonably good transonic and supersonic capabilities. It suffers, however, from structural problems, particularly in torsional stiffness in weight and in space, and in stability, both longitudinal and lateral.

The crescent wing is an effort to combine the root characteristics of the delta and the outer wing features of the straight or slightly swept plank wing. Theoretically this is admirable, from aspects of stability and control, but it is difficult to see how it can possess the space and structural advantages of the pure delta since it has neither the chord of the latter nor the average thickness chord ratio. In achieving a better span loading it needs to be of greater span or less chord than the pure delta and so loses further structural advantage, save by resorting to less area and so going to a higher wing loading, which may well negate its advantages.

The delta planform does appear to provide an extremely reasonable and promising compromise in offering many features in which these previously mentioned forms are lacking :—

(i) Excellent Mach number characteristics as to change of longitudinal trim and rise of drag due to Mach number.

(ii) Low high-speed drag.

(iii) A compact form of sufficient strength to cover high indicated air speeds.

(iv) An internal volume providing space for the masses of ancillaries and equipment with which modern aircraft are burdened, not to forget the not inconsiderable libations required to keep powerful engines happy for reasonable periods.

(v) The ability to cope with future requirements in the line of developments in more equipment, more powerful engines, more fuel and more performance, without major redesign.

It has been said that the delta suffers by virtue of its low aspect ratio and high span loading. This may well be so, were high wing loadings the order of the day, but it is my conviction that the low wing loadings of our British deltas more than make up any losses due to adverse span loading conditions. It has been my personal experience that the low speed handling and general qualities of an aircraft are a measure of its high altitude performance. On this theme I have further noted that behaviour near the static and dynamic stalls is a faithful indication of characteristics under conditions of compressibility.

Provided that the crescent shapes keep their wing loadings down to near those of the deltas they might prove formidable contenders for the honours of the "best," although possibly at serious disadvantages as regards compactness and stiffness which might well impose low altitude speed limitations, internal storage capacity and doubtless loss of drag efficiency by virtue of large separate bodies and empenages, which brings up the questions of tails on deltas—"to have or to have not."

There is much to be said for dispensing with horizontal tail surfaces with consequent reduction in drag, saving in weight and mechanical complexity, for perhaps certain losses at the extreme end of the speed and Mach number range. It was felt in the case of the "Javelin" that the design must be exploited to the full at both ends of the performance range and so, on the basis of existing knowledge, flaps were provided and a separate high mounted tail unit to provide stability at both low speeds and very high speeds and Mach numbers. This policy certainly appears to have paid dividends so far.

The "Vulcan," on the other hand, is undoubtedly the soundest conception for its role, which, in all likelihood, is not to such severe requirements for high speeds and Mach numbers and manœuvrability as the fighter, but must achieve the best possible weight/load ratio coupled with the most advantageous high speed drag coefficients. A further point here is that fighters may be expected to have a power/weight ratio of about 0·5, whereas that of a laden bomber is not likely to be more than of the order of 0·3. As to the landing case it is to be remembered that a fighter normally comes in at about 70 to 75 per cent of its all-up weight, whereas the bomber normally lands at about 50 to 60 per cent of its laden weight. Thus, each would appear to be the best solution within the limitations of the specification to cover the intended role of each.

Performance-wise, the deltas have certainly not been lacking, while handling qualities have been surprisingly "ordinary." Practical experience with deltas has shown that they are normal aeroplanes and that they are practical, easily handled aircraft without, so far, any revealed deficiencies peculiar to themselves. Problems there are and have been, but only those of the same nature and magnitude experienced with modern, high performance aircraft of more orthodox shape. Changes and modifications may perhaps be expected as time goes on, but, most important of all, the delta is a relatively new aeroplane, yet as such it is already more than holding its own with designs which represent years and years of step-by-step progress.

Vision at Altitude

High altitudes of 40,000ft and upwards present problems of vision and sight not generally appreciated by laymen. These must be of increasing awareness to pilots, staff and planning personnel, since they cannot but have effects of considerable import on all concerned.

Glare and Ultra-Violet Light.—The lack of dust particles, water vapour and haze, which are generally encountered low down, result in sunlight of extreme brilliance and of considerable embarrassment in its effects on the human eyes. Filters, goggles and visors can moderate these effects to some extent, but they are prone to misting, make reading of instruments more difficult and, in general, are not completely satisfactory. Severe sunburn can result from prolonged exposure at high altitudes.

Lack of Contrast.—Lack of proximity to cloud masses with high or distant cloud taking on a greyish hue as the sea or earth usually does, results in a rather limited colour scheme, the only relief being the blue sky. A camouflaged aircraft blends into this indefiniteness and so is extremely difficult to pick up among its surroundings. The fact that there is so much space with no horizontal or vertical features of prominence such as cities, shorelines, mountains, hills or rivers, or even cloud masses, makes the picking up of targets extremely difficult. In one's own experience, if one tries to search out an aircraft in an expanse of sky, or a swimmer in the sea, knowing only the general direction, one knows how difficult detection can be.

Focusing.—Another problem facing aircraft crews is the necessity of not only searching and straining their eyes in space, to extreme range, but also the necessity of being able to see and operate the instruments and equipment within the cockpit, and only a few inches from the eyes. Shifting from one to another means a constant disruption to the focusing of the eyes. Designers and manufacturers may well take note of the aid which can be given crews by making instruments quickly and easily readable, or better still, ensuring engine and aircraft control which does not require reference except at very occasional intervals.

High relative speeds, except in the case of stern chases, mean that the time other aircraft may be in sight is very short indeed since the range of human vision at high altitudes is not likely to be more than about 5 to 8 miles, considering the size of aeroplanes. This means that another aircraft, on a 90 deg. crossing path, will be in the pilot's range of vision not over a minute. A machine approaching head-on will only be picked up a matter of 15 seconds or less before being opposite another.

Navigational Aspects.—Air to ground vision with even the excellent view generally provided in jet aircraft is much reduced at altitude, increased height resulting in increased blind areas in respect to the ground. As an illustration: in an aeroplane with good side and forward vision of 12½ deg. over its nose, in level flight at 40,000ft, the pilot cannot see anything under about 35 miles away, rising to about 60 miles at 5 deg. incidence. To either side he is not likely to see anything closer than about 20 miles and so, without resorting to manœuvring, is blind to at least some 1600 square miles below him and more at greater heights. At low altitudes at even 600 m.p.h. a landmark which can be discerned 5 miles away must be identified in the 30 seconds before it recedes behind the aeroplane. Also in climb/descent or direction, 1 deg. deviation from course results in 1000ft per minute rate of climb or descent, or 5 deg. off course causes an aircraft to be roughy a mile off track for every minute. The difficulties of navigation and target detection, especially in conditions of poor or bad visibility, are therefore clearly apparent.

Economics of Modern Aircraft

Of ever increasing importance in these days is the increasing complexity and cost of modern aircraft. One can remember the days when it was predicted that the jet engine was going to bring with it a new era in simplicity and economy of manufacture and operation. Unfortunately this has not been the case of either the engine, the airframe or its equipment, all of which have grown with the demands of increased performance and operational requirements. In its infancy the jet aircraft was looked upon, and indeed suggested, as a very much simplified aircraft, both from the aspect of its airframe and engine.

Smaller undercarriages much reduced in weight by the introduction of shorter legs and lower ground clearance made possible by elimination of propellers were promised. This may have been true of the "E1/44," "Vampire" and possibly the "Meteor," but it is certainly not true of our latest aircraft with higher mounted wings. Anyone doubting this statement would do well to look at one or both of our latest day fighters parked alongside an "F.86."

Hydraulics have, if anything, increased with the addition of air brakes and the increased operating requirements of the main services. The necessity of boosted and power controls, and the general increase in operating pressures, has increased weight and complexity. There is evidence, however, that further hydraulic complexity and equipment is essential for flying controls in particular.

Electrical requirements have gone up markedly with the adoption of electric canopy operation, electric trimming of control tabs and particularly tailplanes ; added radio, radar and Gee equipment, new sighting and fire control equipment, as well as possible provision for more complex bombing and rocketry. Furthermore, the adoption of electrically-controlled main services, auto-stabilisers and instruments, blind flying aids and apparatus, plus navigational aids, have all added to the overall complexity and weight.

While "electrics" are no doubt a very pleasant and desirable way of accomplishing the

many tasks around an aeroplane, manufacture and maintenance require specialist personnel in large numbers, as well as considerable test equipment and facilities. There are many problems, of corrosion, brush wear at altitude, heating, pressurisation of certain equipment, cooling and shock mounting, yet to be solved.

Of all equipment on aircraft, as in motor-cars, "electrics" are probably the greatest source of failures and for that reason not at all popular with pilots. Electrical failure is usually complete, and rarely partial, as in the cases of hydraulics. Furthermore, damage can have rather serious secondary effects, such as fire.

Instruments.—As with other requirements, instruments have grown in number, not only to deal with the added equipment, but to enable close control of the engine which, unfortunately, has not lived up to its advance notices of simplicity. No effort to reduce size or weight, as in America or Czechoslovakia, has been apparent in the United Kingdom, usually on the score of accuracy, yet our more recently introduced instruments appear to be worse in this respect than their predecessors. Scales could be reduced advantageously in many cases to show only a small portion of the cruising range with the accent on the range of limitations, plus a danger range. Reduction in size is most pertinent, since great accuracy is of no virtue when of necessity it is negated by parallax through positioning, or positioning well outside the easy range of the pilot's vision.

This may well be the time to speak up on warnings—one school of thought has decreed that warning lights and emergencies should be with the appropriate control requiring action. This is all very commendable, and would be so if such controls were on top of the instrument panel, but this is not the case and the warning as such is almost valueless since it is rarely seen when it first appears. Since the purpose of a warning is either to let the pilot know emergency action is required, or in some cases preventive action, the important thing would seem to be that the pilot received indications at the earliest possible moment. This dictates that the indications be in his line of V.F.R. or I.F.R. vision (i.e. on the combing or on the top of the instrument panel) and it is suggested that they should all be grouped in one spot, preferably a small panel, say, 4in by 4in or 2in by 6in. They might also be of two distinct types, say, yellow and red, plainly marked in an easily learned logical order (e.g. engine fuel system warnings on the same side as fuel indicators or controls), the first to indicate a patently dangerous but not necessarily a panic warning (i.e. low fuel pressure or high bearing temperatures), which by an alteration of power the pilot could prevent damage and subsequent failure. The red warning would indicate a dangerous condition such as fire, requiring immediate action or evacuation of the aircraft. The pilot, therefore, is warned at the earliest possible instance, is made to think and sort out his action before doing anything premature—and the danger of missing the warning is eliminated.

A saving in space would result and as a further development, why should not a series of three types of lights be used (green, amber, red) to replace engine, fuel pressure, oil pressure, hydraulics and perhaps certain temperature and electrical indications.

Engines.—The comparatively simple jet engine has never been notoriously cheap even in its original centrifugal form, which, at least, had the virtue of relatively few moving parts but yet required expensive, often difficult to work, metals and alloys to be manufactured within extremely close tolerances and to be fitted, adjusted, assembled and balanced to very fine limits. Any relaxation in these matters spelt short life and inferior performances. Had we been content with moderate thrusts, the advertised blessings of simplicity and long life might well have materialised, but the uprating of engines, together with their characteristics of control, especially at altitude, have caused more failures and lower overhaul periods than were anticipated. As this has been so with centrifugal engines, so to a much greater degree has it been with the axial flow engines with their 6000 to 7000 compressor blades and multi-stage turbines.

A period spent in the aircraft industry of North America was a revelation as to the vast amount and variety of "off the shelf materials," components, ancillaries and equipment available to designers and fabricators. Another "eye opener" was the aggressive competition of the manufacturers of these articles in producing more attractive products as to size, weight, reliability, cheapness, air crew utility and appeal—a feature most conspicuously absent in British firms, which, in all fairness, may be too rigidly bound by official requirements to exercise much initiative on their own.

It would be interesting to know the number of stock components on two roughly similar American aircraft, compared with two British aircraft of a similar specification. Certainly in the case of the latter virtually everything about a new aircraft is prototype. This may be an excellent thing in maintaining design staffs, testing sections and experimental shops, but it cannot but play havoc with the Air Estimates. I know "maximum efficiency" will always be quoted but is it not a worthy challenge to the ingenuity of the designers to build their various aircraft configurations around fewer, more standardised, ranges of components and equipment? Surely one type of undercarriage or tailplane actuator, to quote but two examples, could be made to do for virtually all aircraft built to a similar specification as to weight and performance? Surely this must be one of the solutions to the cheap fighter or for that matter, cheaper aeroplanes of all types.

A Range of Middleweight Trucks

DETAILS of a new range of middleweight trucks, now in full production, have been announced by Vauxhall Motors, Ltd., Luton. This range embodies vehicles of payloads from 20/25 cwt to 5 tons, and it supersedes the existing "K.M.O." range of Bedford vehicles, of which over 400,000 vehicles have been built since 1937. The 10/12-cwt van and the 7-ton vehicles continue unchanged.

Of this range the chassis frame and the cab are the only entirely new major units. Some

Three-Point Cab Suspension

modifications have been incorporated in the steering and front axle, but the engine, gearbox and back axle details remain unchanged.

This new "A" series comprises five different models, all of normal control, and ranges from a 20/25-cwt chassis of 119in wheelbase, having a maximum vehicle weight of 3 tons 2½ cwt, to a 5-ton chassis of 120in and 167in wheelbase, with a maximum weight 8 tons ¾ cwt. A tractor unit for articulated vehicles of 120in wheelbase weighs 12 tons 1 cwt.

The design of these chassis is rationalised for maximum interchangeability and simplified fleet maintenance.

On 4 and 5-ton models (including "artic" tractor unit) a Perkins "P.6V" diesel engine is available as a factory-sponsored, factory-fitted alternative. With this engine a heavier clutch and special axle shafts are fitted.

A completely new and ultra-rigid, all-steel, three-seater cab is standard throughout the series. It is manufactured as a single assembly, with front wings, bonnet and grille. This assembly, including the radiator, rides on three rubber mountings, to permit maximum chassis frame movement without cab distortion. It is claimed that this construction provides a higher standard of riding comfort for driver and passengers and a longer cab life. The engine, which is well forward of the cab, leaves plenty of room for the centre passenger, and the gear lever and hand brake are out of his way. An adjustable driving seat having 5in of fore-and-aft movement is fitted.

Insulation against engine heat and noise is provided on dash, toe-boards, floor and engine cowl, and the roof, back and door panels are double skinned. Doors are fitted with sponge rubber and apertures with tubular weatherstrips, to keep out dust and draughts.

A 20 square inch scuttle ventilator directs air down into the cab and around the feet of the passengers. No-draught windows, forward of the main windows, can be turned right round to act as air scoops.

The dash panel is similar to the Bedford 7-ton model, but space has been provided for the installation of heater and radio.

Stiffer chassis frames are used on the 4-ton and 5-ton models than on the previous designs, with side members now 8·88in deep and 0·25in thick. Longer front springs have also been adopted.

All models have also an improved version of the semi-irreversible worm and sector steering gear with a steering box ratio of 21 to 1.

The unchanged mechanical details include the engine introduced in 1950 of 76 b.h.p., on "A2" and "A3"; 84 b.h.p. on the 4 and 5-tonners; the synchromesh gearbox; hypoid rear axles, on 4 and 5-tonners; and the Bedford hydraulic braking system, with tandem master cylinder and vacuum servo assistance.

The standard dropside truck bodies now have pressed steel cross bearers to the underframe. Floorboards are now clamped to these cross bearers with longitudinal metal wearing strips.

Recovery of Laminated Spring Leaves

WE have received from London Transport some notes on a system for the recovery of laminated spring leaves from its buses and coaches, which has been introduced at its Chiswick works and has reduced expenditure for new springs and minimised demands for steel.

Under this system leaves from springs withdrawn from service and which are not obviously scrap are cleaned and sent to the recovery section for sorting into batches according to width and thickness, and length in 6in steps. Each batch of springs is then passed to a magnetic crack detector, where the operator marks with red paint the extent of any crack that may be detected.

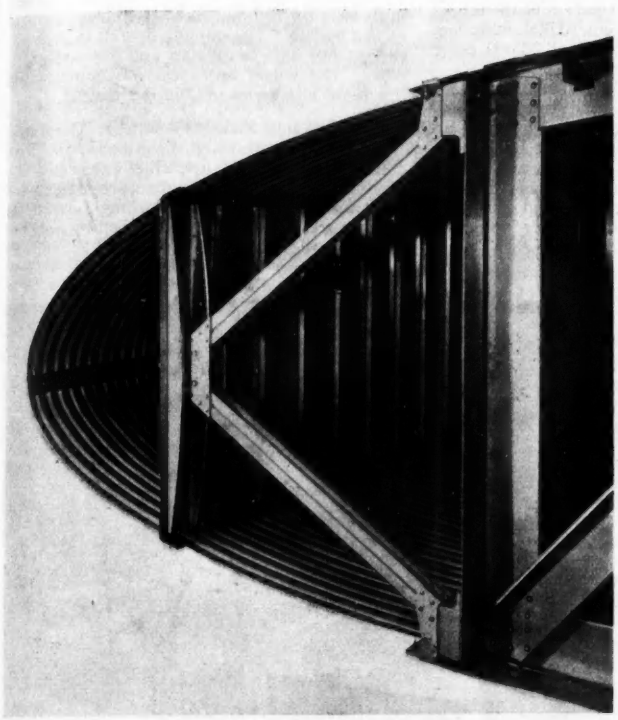
The marked leaves are transferred to a bench provided with sets of sheet aluminium templates of the various leaf sizes used. Each template incorporates a stencil of the part number of the component it represents, and, at the centre, a circle for the locating dimple. The operator selects from the appropriate set the longest template which can be accommodated in the sound portion of a fractured leaf and marks on the leaf, with blue paint, the length to which the sound portion is to be cut, the part number and the place for the dimple. After marking, the leaves are sorted for cutting to the respective lengths and stored. When this first part of the recovery routine is completed the supplies officer is notified of the quantities of various part numbers ready for remanufacture.

Actual remanufacture is not carried out until orders for particular leaves are received, after which the normal process of spring manufacture is followed. In the smiths' shop the appropriate leaves are cut to the marked lengths by oxy-acetylene flame, and the corners are cut off. The centre of each leaf is heated locally for the formation of the locating dimple and the leaves are then heat-treated.

Metal-to-Metal Bonding in Aircraft

THE relation existing in an aeroplane between the structure weight and the fuel load to the maximum, all-up weight, has always rendered the margin for pay load a slender one. So slender is this margin in jet propelled aircraft on account of the much heavier fuel load involved that the need to reduce the characteristic structure weight ratio has been made imperative. Methods currently being developed which promise to effect a significant gain in this direction are related to the abandonment of riveted fabrication and the adoption of integral construction techniques and methods of metal-to-metal bonding.

Some matters relating to this development were discussed recently by Dr. de Bruyne, of Aero Research, Ltd., on his return from a lecture tour of the United States. In that country he maintained that most interest was centred on the method of producing integral skin and stringer panels by machining from solid slabs. This method, he stated, involved removing up to 60 per cent of the metal by weight as swarf. Other work was connected with the casting of such integral units in magnesium alloy.



Bonding in the Leading Edge of the "Britannia" Wing

Development in this country, so far, Dr. de Bruyne suggested, were along very different lines and depended on the technique of metal-to-metal bonding, using the "Redux" process. This process, which was invented by Dr. de Bruyne, is now relatively well-known in this country and its use on the "Comet" and "Britannia" aircraft are generally accepted as having made an indispensable contribution to their success.

To illustrate the necessity for new methods of construction, Dr. de Bruyne referred to the following figures, representative of the "Comet" Mk. I, given on the table herewith.

Using a simple analysis due to Dr. A. E. Russell of the Bristol Aeroplane Company (*Inst. Prod. Eng. Journal*, 32, February, 1953, 86–94), the economic consequences of pushing up the E/G ratio to 48 per cent while retaining the same performance as the "Comet" Mk. I, are shown on the right-hand side of the following table. On comparing the two sets of figures it will be seen that the empty weight has gone up by 19,500 lb. That is to say, this small increase in E/G has resulted in a much heavier and more powerful machine and will cost the purchaser £9 × 19,500 (which is £175,500) more. According to information provided by Mr. Peter Masefield, the annual operating costs will be increased by £50 × 19,500, which approaches £1,000,000 a year. It was clear, Dr. de Bruyne continued, that the hypothetical "Comet" would have found no buyers. He believed that had "Redux" not been used, the "Comet's" E/G might well have been 48 per cent or even more.

	"Comet" Mk. I	Hypothetical "Comet" using riveted construction
Empty weight/gross weight	45 per cent	48 per cent
Fuel weight/gross weight	42 per cent	42 per cent
Pay load	14,000 lb	14,000 lb
Fuel load	44,000 lb	58,000 lb
Empty weight	47,000 lb	66,500 lb
Gross weight	105,000 lb	138,500 lb

Our illustrations show two applications of the "Redux" process. The particular application shown in the pressurised fuselage of the "Comet" relates to the window mountings and the skin and stringer bondings.

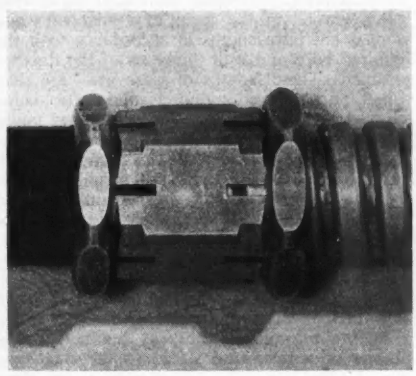
In recalling other impressions of his tour, Dr. de Bruyne thought that the use of "Redux" in this country had been much more imaginative and bold than anything he saw in U.S.A. That may be because the hard economic facts of jet transport had not yet struck them. On the other hand, he had seen metal honeycomb constructions in pilotless aircraft, which appeared superior to anything done in this country. The superior technical qualities of British aircraft design were admitted, although the Americans were convinced that in their production methods they were far ahead of us. Some plants were truly enormous, and certain of their bonding techniques were very ingenious and, although we had nothing to learn from them about adhesives, he had learned something about techniques of applying pressure and of ensuring smooth surfaces.

Some Bonding Details of the "Comet" Fuselage

A Conduit Coupling

A NEW coupling unit for electrical conduits, now being made by Abboflex, Ltd., 25, Ferry Road, Teddington, Middlesex, under the trade name of "Abcon," can be used for connecting lengths of rigid conduit or, as shown in our illustration, rigid to flexible conduits.

Each coupling has a long hexagonal shell body, bored to fit freely over the conduit ends, and in this body slots are machined down the flats for some distance at each end. A length of thread is cut on a short annular extension at each end of the body. When nuts having tapered threads are screwed on these extensions they serve to press the body sections between the slots inwards to grip the conduits and hold them firmly together in alignment.



Coupling Connecting Rigid and Flexible Conduits

When the coupling locking nuts are unscrewed the body ends spring open to free the conduits.

Manufacture of Heat Insulating Sections for Pipes

A CONTINUOUS semi-automatic production line for making rigid sections of heat insulating material has been laid down at the works of Fibreglass, Ltd., St. Helens, Lancs. The new method of production and the equipment installed in addition to reducing the time required for manufacturing, has made it possible to control the standard of quality very closely.

As is generally known, "Fibreglass" rigid sections are used for the insulation of hot and cold water pipes and steam pipes. They are moulded from glass wool bonded to a density of 10 lb per cubic foot, and have an outer cover of canvas or scrim cloth. The sections are 3ft long and are manufactured in the following sizes :—½in thick, to fit all pipe sizes from ½in to 4in bore inclusive, and from ½in to 2in thick, in ½in increments, to fit all pipe sizes from ½in to 12in bore inclusive.

The moulded sections are split in half longitudinally and have an outer covering which acts as a hinge. Canvas covered sections have overlaps at one end, as well as along the longitudinal edge, to ensure a neat finish when they are applied to the pipe.

At the beginning of the manufacturing process "Fibreglass" in the form of a mat of white wool is cut into lengths in accordance with the required bore and wall thickness of the finished product. These lengths of glass wool are then rolled on to waxed mandrels and, after being sprayed with a binding agent, are formed under pressure into sections of a determined density, bore and wall thickness. The mandrels, with the sections still on them, are then loaded on racks or bogies which are pushed into one end of the 110ft long continuous drying oven, to be seen in the illustration on this page.

This drying oven was designed and built by Controlled Heat and Air, Ltd., of Smethwick, Birmingham, and a continuous tunnel oven. It is divided into four sections, each of which is maintained automatically at graduated conditions of temperature suited to the stage and period of drying. Each oven section has three separate heating systems, arranged for direct gas firing. Each of these systems operates under close thermostatic control and incorporates electronic safety devices which shut down in the event of flame, fan or electrical failure. The oven is of double-cased construction and the space between the walls is filled with "Fibreglass" resin-bonded slabs of 4½ lb per cubic foot density. The heater casings are insulated similarly, but with slabs of 8 lb per cubic foot density.

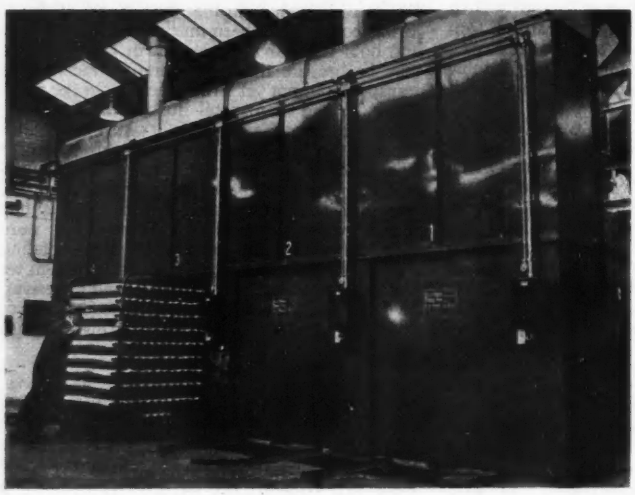
As already mentioned, each tunnel is graduated in temperature and humidity and the air flow is against the flow of work so that the wet sections when placed in the feed end of the oven are processed in air having a high relative humidity. This humid air speeds up the heating process because of its greater total heat, as compared with dry air.

A rapid circulation of air is essential to promote efficient drying in this design of oven and there is maintained in each heated section of the tunnel a circulation of not less than 10,000 cubic feet of air a minute, giving a total of 30,000 cubic feet per minute in each tunnel.

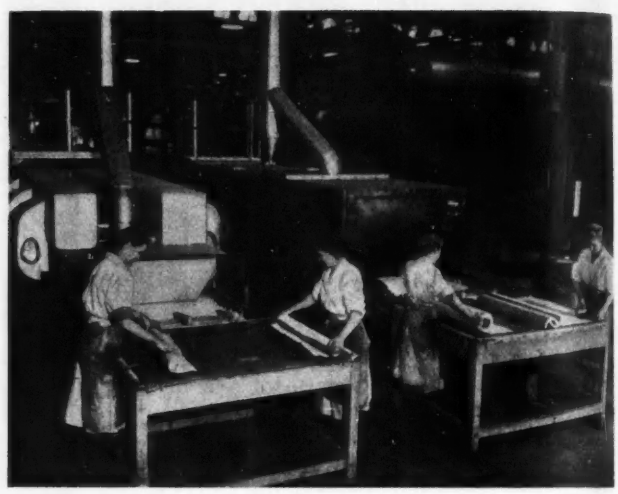
Specially designed ducting directs the conditioned air over and around the sections as they lie on the bogies, the air then being picked up by recirculating ducting situated at the top of the tunnel. The system is so adjusted that a predetermined air volume is always moving forward against the work flow and gathering more moisture on its travel. After doing its part of heating the cold work at the loading end this air is extracted and discharged to atmosphere.

The bogies are guided through the tunnels by dragline conveyors which are interlocked with the automatically operated, counterbalanced doors. The drying cycle takes between twenty and forty-two hours, depending on the size and wall thickness of the sections. The ovens are capable of removing 1 ton of moisture per hour, the actual gas consumption of each tunnel being in the region of 1930 cubic feet per hour and representing a thermal efficiency of 45 per cent.

When the sections emerge dry from the oven they are stripped from the mandrels, trimmed to 3ft in length, split axially and covered with either calico or scrim cloth. When the covering has been pasted on, overlapping along the longitudinal length and at one end, the rigid sections are placed on the conveyors shown in our second illustration. These conveyors are fitted with special chains which carry the sections through low-temperature ovens for a further drying process. These ovens, which were also designed and manufactured by Controlled Heat and Air, Ltd., are heated by air circulation, and arranged for direct gas firing. Thermostatic controls and a variable-speed gear drive on the unit give drying times of seven minutes to thirty minutes. When the sections emerge dry, the edge with the overlap is opened so that each section is hinged for ease of application.



Loading End of Continuous Drying Oven



Low Temperature Drying Ovens

Continental Engineering News

(By Our Continental Correspondent)

Moving a Bridge in Switzerland

A new highway bridge is now being built over the River Aar at Olten. In order to use the existing bridge as a service structure for erection, it was decided to move it sideways for a distance of about 84ft. The old bridge was built about seventy years ago, being a lattice truss steel structure, 340ft long and 33ft wide, of three spans, of which the central span had a length of 104ft. Its weight was about 850 tons. Four rolling paths were used to move it, the rollers being 6½in in diameter and 20in long. The central rolling paths rested on two rows of piles, each having a bearing capacity of 35 tons, while the side rolling paths were laid on transverse beams supported on a row of piles. Bogie units were formed by rollers assembled in groups of five by five. The moving operation itself was carried out with a capstan and a ½in diameter rope. The whole operation was completed in one night in a series of 20in movements.

The Wanne-Eickel Footbridge, Germany

As previously mentioned in these columns, Herr W. Haupt, chief engineer of the Dortmunder Union Brückenbau, proposed several years ago a bridge design, according to which the superstructure of a bridge is carried by only one girder. This girder, generally of inverted Y shape, is situated on the centre line of the bridge. According to the designer, the advantages of his system lie in a saving of structural materials, a reduction of pier width and the separation of the roadway into two separate carriageways. A footbridge of this kind is now in service over the Rhine-Herne Canal near the town of Wanne-Eickel, Germany. The bridge is a tied arch with only one arch rib, placed at the centre line of the decking, its span being 200ft. The decking is 11½ft in width and forms the tie member of the arch rib ; it is hollow, 2½ft deep, and has sufficient torsional rigidity to ensure the stability of the bridge under unbalanced loads. Its top and sides are of ⅜in steel plate and the bottom is latticed. The top of the decking is treated with a thin plastic layer covered with 1in of asphalt. The total weight of the new bridge is about 61 tons.

A Bridge Between Austria and Bavaria

A new bridge, replacing a structure destroyed during the war, has recently been built across the Inn River, which forms the border between the Austrian town of Braunau and the Bavarian town of Simbach. The new bridge was recently opened to traffic and is a steel plate girder structure, some 965ft long, consisting of five equal spans. The decking has an overall width of 34½ft. The new Braunau bridge was erected by the Vereiningte Osterreichische Eisen und Stahlwerk, of Linz.

Industrial and Labour Notes

The Factory Inspector's Annual Report

The annual report of the Chief Inspector of Factories, Sir George Barnett, for the year 1951 was published at the end of last week by H.M. Stationery Office (price 6s. 6d.). It opens with a survey of the changes which have taken place in industrial organisation in this country during the first half of the present century. A reference of particular interest in this survey is that which is made to the decline in the number of factories without power. The report records that in 1901 there were 95,664 factories with power and 137,648 factories—or workshops as they were then called—without power; in 1951 there were 212,245 factories with power and only 26,464 without.

Dealing with the year 1951, the report shows that, despite world shortages and high prices of raw materials, there was considerable activity both in the establishment of new factories and in the reorganisation and extension of existing premises. There was evidence that greater attention was being given in new industrial buildings to the importance of structural details likely to result in better conditions for the workers and consequently improved output. The Chief Inspector expresses some disappointment, however, with the general layout and amenities of some of the standard factories being erected in the new towns and on some industrial trading estates. Reviewing industrial developments generally, the report stresses the importance of considering safety principles at the stage of planning, alteration or adaptation of factories, pointing out that prior consultation with the factory department of the Ministry of Labour about likely risks may well be more profitable than afterwards trying to remedy faults which foresight might have avoided.

The report states that there were 828 fatal accidents in 1951, compared with 799 in 1950. The number of non-fatal accidents, however, fell by 5 per cent, from 192,260 in 1950 to 182,616 in 1951, the latter being the lowest figure recorded since 1938. The biggest decrease in accidents was in engineering works, and there were also marked decreases in building operations, textile mills and shipbuilding yards. Concern is expressed in the report, however, at the continued rise in the number of accidents connected with transport. In some comments about the accidents which occurred in 1951, the Chief Inspector says that the reports for the year dispelled any doubts about the capacity of people over sixty to do useful work in industry, "many of them defying their years and exercising the skill acquired during a life-time."

About hours of employment in 1951, the report says that the normal working week remained at forty-four or forty-five hours, with a tendency to work overtime up to forty-eight hours. At the end of the year, 1442 orders and permissions were in being to cover day-work schemes and 484 covering shift work, including double-day shift work. The only progressive rise was in the figures for day-work schemes and was largely accounted for by permissions allowing evening employment.

Average Weekly Earnings and Hours

The Ministry of Labour has just published the results of an inquiry which it made last October into the average weekly earnings and working hours of manual wage-earners employed in manufacturing industries generally and in a number of non-manufacturing industries in the United Kingdom. Information on these matters was received from 62,100 establishments, the total number of wage earners covered by the returns being about 6,500,000. In each case the particulars of earnings and hours relate to the last pay week of October, 1952.

The Ministry's survey shows that, in the manufacturing industries generally, the average weekly earnings were: men, £9 4s. 9d.; youths and boys, £3 13s. 1d.; women, £4 16s. 10d.; girls, £3 1s. 2d. When certain non-manufacturing industries—excluding coal mining, railways and London Transport and British Road Services—were considered in conjunction with the manufacturing industries, the figures of average weekly earnings for the last pay-week in October were: men, £8 18s. 6d.; youths and boys, £3 14s. 11d.; women, £4 16s. 4d.; girls, £3 0s. 9d. The Ministry says that, compared with October, 1938, these earnings show increases of 159, 187, 196 and 228 per cent respectively. It says also that there have been increases in the rates of wages in a large number of industries since the inquiry was made. It is estimated that the effect of these increases has been to raise the general level of full-time weekly wage rates in the industries covered by the inquiry by 3 per cent during the four months November, 1952, to February, 1953, inclusive.

In all the industries—manufacturing and non-manufacturing—covered by the inquiry, the average hours worked in the last pay-week of October, 1952, were: men, 47·7 hours; youths, and boys, 44·4 hours; women, 41·8 hours, and girls, 42·7 hours. Comparable figures for October, 1938, were: men, 47·7 hours; youths and boys, 46·2 hours; women, 43·5 hours, and girls, 44·6 hours.

Changes in Wage Rates

The Ministry of Labour has reported that changes in wage rates stated to have come into operation during February in the United Kingdom resulted in an aggregate increase estimated at approximately £543,000 in the weekly full-time wages of about 1,635,000 workpeople. The principal increases were to workers in the building trades, civil engineering construction, and coal mining.

In building and civil engineering construction there was an increase of 2d. an hour for adult male and female workers, which was payable under sliding-scale arrangements based on the index of retail prices. In the coal mining industry the national minimum weekly wages were increased by 6s. for adult workers and shift rates were increased by 1s. a shift for adult day-wage workers. There were also wage increases during February of 2d. an hour for adult male workers in the vehicle building industry, with proportional amounts for other workers, and of 2d. an hour for men and 1½d. for women in the metal finishing industry.

In the first two months of this year changes in wage rates resulted in an aggregate increase of £697,100 in the weekly full-time wages of approximately 2,400,000 workpeople. At the end of February the index of rates of wages (June 30, 1947=100) was 135 for all workers, or one point higher than at the end of December, 1952.

Index of Industrial Production

The index number of industrial production (1948=100), which is prepared monthly by the Treasury, has been estimated provisionally as 116 for all industries in January, compared with 111 for December last. Figures in the corresponding months a year earlier were 118 for January, 1952, and 113 for December, 1951. Taking certain industry groups separately, the Treasury shows that the index for mining and quarrying in January was 117, compared with 110 a year earlier, and for the manufacturing industries 117, compared with 120 in January, 1952. On the basis of information so far received, the index number for all industries in February this year is expected to be 117 or 118.

Copper and Aluminium Prices

The Ministry of Materials has announced this week reductions in the prices of copper and virgin aluminium. As from March 26th the price of electrolytic copper has been reduced from £285 to £280 per ton, delivered consumers' works. At the same time the discount on Ministry sales of blister copper has been increased from £5 to £6 17s. 6d. Other discounts and premiums are unchanged. The Ministry has stated that the price reductions take account of the concessions which the Rhodesian producers have made on the price of blister copper.

As from April 1st the price of virgin aluminium, in ingot form of a purity of 99 to 99·5 per cent inclusive, has been reduced from £166 to £161 per long ton, delivered consumers' works. There has been no change in the premiums which came into effect on July 1st last for aluminium of higher purity and in notch bar form. The aluminium price reduction has been made possible by the improved rate of exchange of the £1 sterling in Canadian dollars.

Industrial Disputes

According to information given in the latest issue of *Ministry of Labour Gazette* there were 176 stoppages of work through industrial disputes in progress in the United Kingdom during February. There were 36,300 workers involved, directly and indirectly, in these disputes, the aggregate number of working days lost being calculated as 152,000. In January there were 140 stoppages of work through disputes, involving 24,900 workers and causing a loss of 60,000 working days.

The majority of the February stoppages occurred in the coal mining industry. In the vehicle building industry, four stoppages were reported in February. One of them, that at the Austin Motor Company, Ltd., Birmingham, began on February 17th and involved directly 2280 workers and, indirectly, more than 6500. The cause of this dispute was reported to the Ministry of Labour as "alleged discrimination against a shop steward when other redundant workers were being re-engaged." Last weekend the company stated that it had discharged 1583 members of the National Union of Vehicle Builders who were still on strike. At the same time it was reported that the executive committee of the union had asked the Minister of Labour to set up a court of inquiry into the dispute.

Coal Production

According to figures supplied by the Ministry of Fuel and Power, the total saleable output of coal in this country last week was 4,706,900 tons. It was made up of 4,476,600 tons from the deep mines and 230,300 tons from opencast workings. The deep-mined production was the highest weekly figure reported this year. In the comparable week of 1952, the deep-mined output of coal amounted to 4,393,600 tons. In the first twelve completed weeks of this year, total coal production was 55,294,900 tons, compared with 54,903,500 tons in the corresponding period of last year.

The Ministry's figures show a slight decline in mining manpower, although the number of face workers continues to increase steadily. In the week ended March 21st, the number of wage earners on colliery books was 719,700—which was 400 fewer than in the preceding week—and of that number 300,400 were working at the face. A year ago the number of face workers was returned as 289,500. Absenteeism in the week ended March 21st is stated to have been 13·43 per cent, compared with 11·99 per cent in the corresponding week of last year. The shifts worked per wage earner in the week before last were 4·97, the output per manshift at the face being 3·18 tons, compared with 3·23 tons a year ago.

Inland coal consumption in the first eleven completed weeks of this year amounted to 50,409,000 tons, or nearly 1,000,000 tons more than in the comparable period of last year. The total amount of coal taken up for exports and bunkers in the first eleven weeks was 3,501,000 tons, compared with 2,738,000 tons in the corresponding weeks of 1952. Distributed stocks on March 21st were returned as 12,712,000. On the comparable date in 1952 they stood at 13,273,000 tons.

Notes and Memoranda

Air and Water

THOMAS GRAY MEMORIAL TRUST.—The prize of £50 which the Royal Society of Arts offered last year under the Thomas Gray Memorial Trust to members of the British Merchant Navy for an essay on "The Future Development of the Cargo Liner," has been awarded to J. W. Killan, first officer of the R.M.S. "Ascania." An additional award of £10 was made to I. S. McLean, chief officer of the M.V. "Ajana."

FISHING BOAT DESIGNERS.—An International Congress, sponsored by the Food and Agriculture Organisation of the United Nations, will be held in Paris from October 12th to 16th, and in Miami, U.S.A., from November 16th to 20th. At the meeting of the Congress, at which Commander A. C. Hardy will act as consultant to the Food and Agriculture Organisation, technical papers will be presented by designers of fishing vessels and their equipment.

FLOATING DEPOT SHIP FOR OIL SEARCH.—The Shell Petroleum Company, Ltd., has purchased the cargo ship "McGregor Laird" from Elder Dempster Lines, Ltd., for conversion into a depot ship for service in connection with the search for under-water oil. The ship, which will be converted on Merseyside, has a gross tonnage of 4081 and will be able to carry stores sufficient for six months, and drilling equipment, and provide air-conditioned accommodation for 150 persons.

DE-SALTING BRACKISH WATER.—Under the auspices of the O.E.E.C. a working party was set up last year to study the de-salting of brackish water. De-salting is a world-wide problem and concerns many countries where water supplies are short or are likely to become so. They include the Netherlands, South Africa, the West Indies and Pakistan. The working party has appointed a group of experts to study four processes which were considered to merit further investigation. They are ion-exchange, separation by freezing, electrolysis and vapour compression distillation. From the information which is supplied by the group, the working party will be able to decide which process or processes call for work on the development scale. The group of experts is now drawing up its report for presentation to the working party. Waters of 1000, 5000 and 20,000 parts per million chloride content have been considered. After the report has been studied the working party should be able to recommend one or more processes for co-operative development to countries of the O.E.E.C., including the United Kingdom. These countries will be free to collaborate or not, as they choose. Those co-operating would, of course, share in the rights of any successful process which may result. Those interested in the progress of the work on this subject are invited to apply to the Department of Scientific and Industrial Research, 5–11, Regent Street, London, S.W.1 for further information.

Miscellanea

PRODUCTIVITY IN THE PRINTING INDUSTRY.—The British Productivity Council has published a pamphlet entitled *A Review of Productivity in the Printing Industry*. The pamphlet reviews recent developments in the printing industry of this country which are in line with recommendations made by the letterpress and lithographic teams which visited the U.S.A. in 1950 and 1951 respectively. The pamphlet is obtainable, at a nominal price of 1s., from the British Productivity Council, 21, Tothill Street, London, S.W.1.

INTERNATIONAL TIN STUDY GROUP.—The seventh meeting of the International Tin Study Group, which was held in London, ended on March 27th. At this meeting it was agreed to set up a working party open to all the members of the group. The working party will consider proposals for international action regarding tin and will report to the chairman of the steering committee of the United Nations Geneva Conference on Tin whether in its view conditions exist for the resumption of that Conference at a suitable date.

WIGAN MINING AND TECHNICAL COLLEGE.—The Wigan and District Mining and Technical College, which is said to be one of the oldest technical colleges in the country and is now in its ninety-sixth session, celebrated Founders' Day for the first time for fifteen years on March 25th, when the principal speaker was Sir Hubert Houldsworth, chairman of the National Coal Board. Dr. E. C. Smith, the principal reviewed the work of the College, which now has over 3000 students. The syllabus includes courses in mining, engineering, chemistry, building, physics, mathematics, biology, arts, commerce, economics and art and crafts. Tribute was paid in the proceedings to the foresight and vision of those who founded the College, and to the contribution which the College was making at the present time to the welfare of the country.

MR. F. P. BEST.—We regret to announce the death, in London on March 26th, of Mr. Frank Powell Best, M.Sc. (Cantab), B.Eng., B.Sc., technical manager of the Marconi International Marine Communication Company, Ltd., and the Marconi Sounding Device Company, Ltd. Mr. Best studied engineering at London University, Liverpool University and, later, at Cambridge, where he gained his M.Sc. and was Alan Brodey Prizeman of Gonville and Caius College. He joined the Radio Communication Company, Ltd., in January, 1924, and was engaged in test work until 1928, when, following an amalgamation, he transferred to the Marconi International Marine Communication Company, Ltd. A year later he was appointed assistant technical manager and in 1932 became deputy technical manager. In 1934 Mr. Best joined Marconi's Wireless Telegraph Company, Ltd., to assist in the development of equipment for marine use, and in 1939 returned to the Marconi Marine Company as technical manager but retained the title of assistant technical manager in the former company, a joint position which greatly assisted technical liaison between the two associated companies. In February, 1940, he was also appointed technical manager of the Marconi Sounding Device Company, Ltd., and later in the same year relinquished his position with Marconi's Wireless Telegraph Company, Ltd., to concentrate entirely upon technical research and development in electronics for marine use.

MR. A. JOHNSTON-SMITH.—We have learned with regret of the death of Mr. A. Johnston-Smith, which occurred on March 19th at his home at Wargrave, Berks. Mr. Johnston-Smith, who was seventy-two, was, until his retirement in 1945, joint managing director of John Howard and Co., Ltd., public works and civil engineering contractors. The earlier part of his career was spent in railway construction work in the Transvaal, Nigeria and China, and for ten years prior to joining John Howard and Co., Ltd., Mr. Johnston-Smith was in charge of the South African branch of Pauling and Co., Ltd.

INSTITUTE OF METALS.—The annual dinner of the Institute of Metals was held at the Park Lane Hotel, London, on Tuesday evening, March 24th, with the president, Professor F. C. Thompson, in the chair. The principal toast was that of "The Institute of Metals and the Non-Ferrous Metal Industries," which was proposed by Air Commodore F. R. Banks, Director of Engine Research and Development, Ministry of Supply. In the course of his speech, Air Commodate Banks said that had it not been for the non-ferrous metal industries there could not have been achieved the aero-engine performances which the world was seeing to-day. The president acknowledged the toast and, at the same time, proposed that of "The Guests," to which reply was made by the Deputy Mayor of Westminster, Councillor A. Sciver.

DIRECT READING EMISSION SPECTROSCOPY.—The Industrial Spectroscopy Group of the Institute of Physics has formed a panel of members interested in direct reading equipment for spectrochemical analysis. These devices combine spectrographs with electronic equipment in such a way that the intensities of characteristic spectral lines give a direct reading of the percentage of the elements present in the specimen. The object of the panel is to organise meetings which would serve the interests of users and potential users of this equipment. The first meeting arranged by the panel took place in the Institute's House on March 26th last, when Dr. A. C. Menzies introduced the subject. Mr. A. L. Pendrey and Mr. R. T. Staples followed with accounts of their experiences in this class of work and there followed a general discussion. Particulars of the group may be obtained from the Secretary, The Institute of Physics, 47, Belgrave Square, London, S.W.1.

Contracts

THE B.B.C. has ordered three medium-power television transmitters from Marconi's Wireless Telegraph Company, Ltd., for delivery in the Spring of 1954. The order includes three 5kW vision transmitters, three 2kW sound transmitters, combining units, monitoring and control equipment for each. The range of transmitters at this power with large aerial is expected to be up to 30 miles.

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., is to build at the Aberdeen yard of Hall, Russell and Co., Ltd., a bulk cargo carrier of the Australian Interstate design for Australian Steamships Proprietary, Ltd. The main particulars of the ship are: length overall 356ft, breadth moulded 50ft 3in, depth moulded 26ft 6in, draught 22ft, deadweight 5500 tons, speed 12 knots, and the propelling machinery will consist of an Ailsa-Doxford oil engine of 2300 b.h.p.

TAYLOR WOODROW CONSTRUCTION, Ltd., Southall, Middlesex, has been awarded a contract for the superstructure of the passenger handling building on the south-east face of the central terminal area at London Airport. The passenger handling building is to be a three-storey building with steel frame and brick cladding. It will take about two and a half years to complete. The contract has been placed by the Ministry of Civil Aviation. The architect is Mr. Frederick Gibberd, F.R.I.B.A., and the consulting engineers are Sir William Halcrow and Partners.

G. AND J. WEIR, Ltd., Cathcart, Glasgow, has received an order from the Anglo-Iranian Oil Company, Ltd., for evaporating and distilling plant for the new refinery at Aden, to provide more than 1700 tons of fresh water daily from sea-water. The order, which has been placed through George Wimpey and Co., Ltd., the civil engineering contractors, is for three triple-effect evaporating and distilling plants, each capable of producing 134,000 imperial gallons of distilled water a day from salt water from the Gulf of Aden, the total output being not less than 400,000 gallons each twenty-four hours, if required. It is expected that the work of erection at Aden will begin early in 1954.

FERRANTI, Ltd., has received a £100,000 order from Royal Dutch/Shell Group to provide an electronic digital computer for use in the Group's research establishment in Amsterdam. The machine will be housed in a new laboratory now under construction. The computer is a development of the one installed in the University of Manchester in 1950 and of that sent last year to the University of Toronto and it incorporates a number of improvements. It will be the first electronic digital computer made by Ferranti, Ltd. for purposes other than academic or Governmental use and will be the first large machine supplied by the company to a commercial undertaking. It will be used for research calculations in petroleum chemistry and engineering.

Personal and Business

MR. P. R. SCUTT has been appointed managing director of Tecalemit, Ltd.

MR. R. C. HUGHES has been appointed production manager of Commer Cars, Ltd., and Karrier Motors, Ltd., Luton.

MR. W. L. HENDERSON has been appointed London sales manager of Dowding and Mills, Ltd., Bordesley, Birmingham, 12.

MR. R. M. ATKINSON, Mr. G. L. Hunter and Mr. W. R. Jones have been appointed directors of George Clark (1938), Ltd.

MR. A. C. MCCARTHY has been appointed representative in Kuwait of Matthew Hall and Co., Ltd., 26–28, Dorset Square, London, N.W.1.

THE FAIREY AVIATION COMPANY, Ltd., announces the retirement of Mr. S. G. Custance, its works manager, following eighteen years' service with the company.

INTERNATIONAL COMBUSTION, Ltd., states that its Leeds office has been moved to National Employers House, Quebec Street, Leeds, 1 (telephone, Leeds 33274).

PETER STUBS, Ltd., Warrington, states that it has appointed Mr. Michael Rolling, 94, London Road, Southend-on-Sea, as representative for the eastern counties.

MR. F. L. WARING, joint managing director of Coalite and Chemical Products, Ltd., has been appointed chairman of the chemical group of the Association of Chemical and Allied Employers.

HADFIELDS, Ltd., Sheffield, has appointed Mr. Alan Brown as sales representative in N.E. England, Cumberland and Westmorland, in succession to George M. Carter (Agencies), Ltd.

MR. L. J. RAY, M.I.Mech.E., has retired from his position as manager of the gear division of George Angus and Co., Ltd., Newcastle upon Tyne. He joined the company's staff in 1924.

THE ELECTRIC CONSTRUCTION COMPANY, Ltd., Wolverhampton, announces the retirement, on medical advice, of Mr. Walter Tonkinson, director and chief engineer. He joined the company in 1898.

MR. B. H. MEARS, director of Associated British Oil Engines (Export), Ltd., and National Oil Engines (Export), Ltd., has been appointed sales director of Mirrlees, Bickerton and Day, Ltd.

THE PLESSEY COMPANY, Ltd., Ilford, announces the appointment to its executive board of Mr. Alfred Blount. The company also announces that Mr. R. I. Hughes has joined its administrative establishment.

FISHER AND LUDLOW, Ltd., Birmingham, has opened a new area office at Clifton Lodge, Park Crescent, Victoria Park, Manchester, 14 (telephone, Rusholme 6307). Mr. R. H. Taylor is the area sales manager.

SIR JOHN DALTON has been appointed chairman of W. T. Henley's Telegraph Works Company, Ltd., in succession to Sir Montague Hughman, who has retired from the chairmanship but will continue to serve on the board of the company.

BARCLAY, CURLE AND CO., Ltd., Whiteinch, Glasgow, announces the retirement of Mr. George Barrie from the chairmanship and from the board. Mr. James Gilchrist, the present vice-chairman, will succeed Mr. Barrie as chairman of the company.

MR. A. R. NEELANDS has been appointed chairman of the Cementation Company, Ltd., 39, Victoria Street, London, S.W.1, and is suceeded as managing director by Mr. W. A. Pickersgill. Mr. P. D. Tolhurst has been appointed a director of the company.

WHITE'S MARINE ENGINEERING COMPANY, Ltd., Hebburn-on-Tyne, announces that its owner, Durham Chemicals, Ltd., has sold the complete shareholding to private shareholders. The present management is to be retained under the managing director, Mr. J. M. Bazin, but there will be some additions to and changes in the board.

FINA PETROLEUM PRODUCTS, Ltd., states that, following the acquisition of Universe Petroleum Company, Ltd., Mr. H. W. Smith has been appointed south-east regional manager, and Mr. J. E. Cook, deputy regional manager. The company's south-east regional offices have been transferred from Hammersmith to 6, Broad Street Place, London, E.C.2 (telephone, London Wall 6881).

MR. F. R. MOBERLY has resigned from the board of Richardsons, Westgarth and Co., Ltd., and has relinquished his appointment as secretary of the company. Mr. J. M. Ireland has been appointed secretary. Mr. H. Fothergill, Mr. T. B. Hall, Mr. J. Liddell, Mr. J. E. Smith, and Mr. B. B. Wyatt have been appointed to the board of Richardsons, Westgarth (Hartlepool), Ltd.

THE RENOLD AND COVENTRY CHAIN COMPANY, Ltd., Manchester, announces the retirement of Mr. R. O. Herford from the office of managing director, after forty-four years in the company's service. He continues as a director. Mr. O. Bertoya has been appointed managing director, Mr. W. S. C. Tully, deputy managing director, and Mr. W. V. Foley, general sales manager.

THE CAPE ASBESTOS COMPANY, Ltd., 114–116, Park Street, London, W.1, states that it has completed arrangements for the production of inorganic fibres from a natural rock deposit in Scotland. The sole distributor of this material, which is known as "Rocksil," is William Kenyon and Sons, Ltd., Dukinfield. The Cape Asbestos Company, Ltd., states also that its subsidiary, Marinite, Ltd., has acquired factory premises at Germiston, Glasgow, for the production of boarding for ship joinery work.

British Patent Specifications

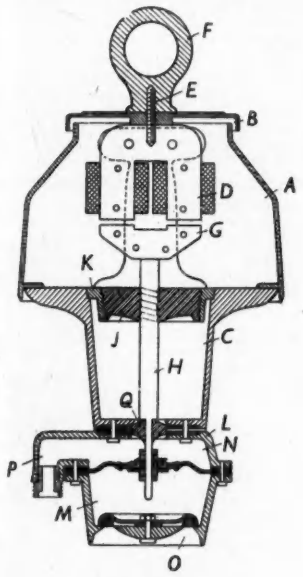
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 6d. each.

ELECTRICAL ENGINEERING

687,756. February 1, 1951.—ELECTROMAGNETICALLY OPERATED PUMP, Enrique Clapes Massons, 18, Mendez Nunez Street, Barcelona, Spain.

Referring to the drawing, the body of the pump consists of a casing *A* having a cover *B* arranged on its upper end and a closure *C* mounted on and closing the larger base, the parts being screwed together. In the upper cover is provided an electromagnet *D*, supported by the screw *E* screwed into an outer ring *F*. Opposite to the poles of the electromagnet is a movable armature *G*, which is integral with a vibrator shaft *H* and carried by an elastic support *J*, which is



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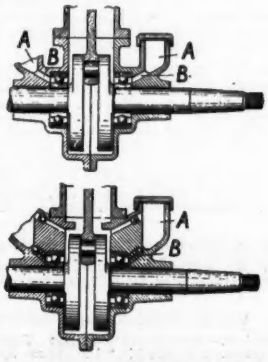
in turn carried by a member *K* secured to the cover *C*. The elastic support *J* forms a guide for the vibrator shaft and permits the vibrating movement of the shaft when it is attracted and repelled by the electromagnet. In the lower part of the cover is mounted a housing *L* divided into two chambers *M* and *N*, the first for the suction of the liquid and the second for its delivery. The suction chamber has an annular inlet *O* for the liquid and the delivery chamber an outlet *P* for the liquid which is provided with a suitable connection for a delivery pipe. To prevent the liquid entering the cover there is provided between the cover and the chamber *N* an elastic joint *Q*, through which passes the shaft *H*, the joint serving as a further guide for the shaft in its axial displacement.—*February* 18, 1953.

INTERNAL COMBUSTION ENGINES

688,083. December 19, 1950.—LUBRICATION OF THE BEARINGS OF TWO-STROKE ENGINES, Societé D'Appareils de Controle et D'Equipement Des Moteurs (S.A.C.E.M.), 190, Avenue de Neuilly, Neuilly-sur-Seine, France.

The drawings show a standard arrangement of a two-stroke engine with the crankshaft supported



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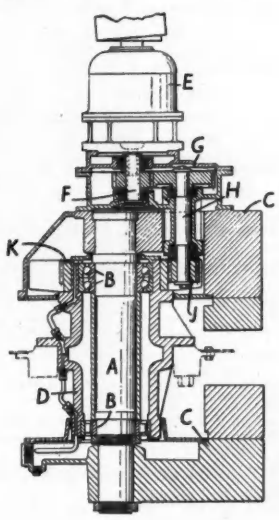
by two ball bearings. Above each bearing there is formed an airtight chamber *A* which has a carefully selected volume of about 10 per cent of the maximum capacity of the crankcase. The bottom of the chamber, as shown in the upper view, communicates by the passage *B* through the bearing with the interior of the crankcase. During the descent of the piston and the precompression of the carburetted mixture, the pressure in the crankcase and the chamber *A* both increase, and there is set up a flow of mixture from the crankcase to the chamber. At the end of the downward stroke, when the transfer ports open, the pressure falls suddenly and the flow of carburetted mixture is reversed. During these exchanges a considerable quantity of the carburetted mixture, which may contain oil, passes through the bearing and lubricates it. Good lubrication is thus provided and no circulation of the mixture through the bearings takes place. The proportion of lubricating fluid is increased if the chamber is cool enough to condense the liquid present in the carburetted mixture which, in turn, produces a more active circulation of the mixture through the bearing. The efficacy of the method described can be still further increased by providing a top passage to introduce the mixture into the chamber, while retaining the lower connection *B*, for the reverse flow through the bearing into the crank case. As shown in the lower view, both of the lower passages *B* are controlled by a simple form of spring-loaded ball valve.—*February* 25, 1953.

SIEVING MACHINES

687,975. October 9, 1950.—FREE-SWINGING ROTARY SIEVING MACHINES, Henry Simon (Holdings), Ltd., Bird Hall Lane, Cheadle Heath, Stockport, Cheshire, and John Stephen Ball, of the company's address.

The drawing shown is a free-swinging rotary sieving machine or plansifter constructed in accordance with the invention. The machine has at its centre a vertical shaft *A* journalled in bearings *B* and having eccentric weights *C* fixed at its opposite ends. The centres of gravity of the two weights are in the same vertical plane so that when the shaft is rotated the resulting forces in reacting against the bearing housing *D* cause the free-swinging section of the machine which is coupled to the housing to gyrate in a horizontal plane, the position of the centre of gyration being a function of the relationship of the rotated mass to the free-swinging mass. The



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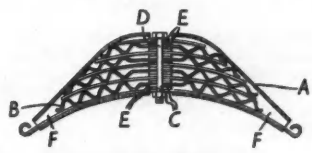
driving motor *E* is mounted so that its shaft *F* is vertical and coaxial with the centre of gyration of the free swinging mass, the motor stator being rigidly fixed to and revolving with the gearbox *G*, in which the shaft *F* is journalled and which forms part of the revolving unit, the normal movement of which induces the gyratory motion of the free-swinging section of the machine. In the gearbox *G* the motor spindle is geared to a shaft *H* which extends through the upper balance weight so that a spur wheel *J* carried at the lower end of the shaft engages with a gear wheel *K* secured to the journal bearing housing *D*. Rotation of the motor spindle therefore causes the spur wheel to rotate and move around the wheel and the housing, carrying with it the gearbox and the motor stator, together with the balance weights and shaft. Upon starting, the motor has a planetary motion, but due to the forces exerted by the balance weights such planetary motion is gradually transferred to the shaft *A* and the free swinging section of the machine as the motor speed increases. When running at rated speed, the motor is stationary in space but with its rotor and stator rotating at different speeds about their geometric centre.—*February* 25, 1953.

ROAD TRANSPORT

688,182. December 4, 1951.—VEHICLE SPRINGS, Firman R. Brooks, 4644, E. 14th Street, Alfred Jack Turner, 4318, East Flower, and Leonard Milton Sheibley, 501, East Jacinto, Tucson, Arizona, U.S.A.

Referring to the drawing, a vehicle spring is composed of several spring leaves *A* and also several other combined spring and lubricating leaves *B*. The spring leaves and lubricating leaves are all longitudinally bowed in the same direction as shown, and are provided with aligned apertures *C* for receiving the shank of a bolt and nut *D*. Either the lubricating leaves or the spring leaves, preferably the former, may be provided with thickened central portions around the openings or spacing



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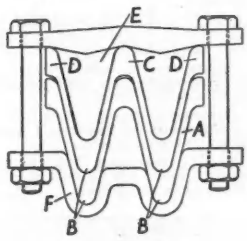
washers may be interposed between intermediate portions of the spring leaves and lubricating leaves as indicated at *E* for spacing purposes. As shown, the lubricating leaves *B* have undulating end portions which contact the spring leaves at spaced points only and the spring leaves are held in spaced relationship to one another by the undulating ends of the lubricating leaves and the spacing elements *E*. The spring unit is enclosed in a conventional cover formed of the corresponding halves *F*, each of which is provided with outside openings through which a lubricant of a non-fluid type such as a grease may be applied.—*February* 25, 1953.

MINING ENGINEERING

688,377. June 9, 1949.—GIRDER STRUCTURES FOR MINES, Margot von Linsingen, 33, Bluecherstrasse, Bochum, Germany, trading as Bochumer Eisenhuette Heintzmann and Co.

As can be seen in the drawing, the support members of W-shape in cross section each consist of four webs *A*, thickened lower end parts or junctions *B*, one thickened upper end *C* and two thickened end flanges *D*. The two main axes of the moments of resistance are arranged perpendicularly relatively to one another



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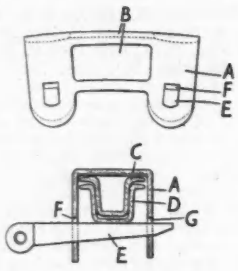
and at right angles to the longitudinal axis of the member. All the members of one girder structure are identical in cross section, their ends overlapping as shown. They are held together by a clamp consisting of plates *E* and *F*, tightened by bolts in such a way that the overlapping ends can move telescopically in their longitudinal direction under the roof pressure but are prevented from being separated.—*March* 4, 1953.

688,393. May 8, 1950.—SUPPORTING STRUCTURES OF SLIDING FRAME ELEMENTS, Regie des Mines de la Sarre, 1, Triererstrasse, Sarrebruck, Sarre Territory.

The invention relates to supporting structures—such as straddle frames used in mine galleries—comprising frame elements, one of which can slide within the other. The shoe-like member shown in the drawing consists of a part *A* which is U-shaped in cross section and in which there are formed cut-away parts *B* in the top and sides. The base of the shoe member is curved in its longitudinal direction and is arranged to embrace the frame elements *C* and *D*. These elements are similar in cross section and of channel section with outward extending flanges at the open edges of the channel, and are curved in their longitudinal direction. The elements *C* and *D* are held in place by locking pins in the form of wedges *E* driven through pairs of guiding apertures *F* and *G*, facing each other and

made in the side walls of member *A*. Each wedge engages the part *D*, presses the parts *C* and *D* directly against each other and presses the part *C* directly against the shoe bottom. In this way the wedge exerts pressure along a radius of the arc provided



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by the base of the U-shaped shoe member. When it is desired to adjust the relative positions of the parts the wedges are withdrawn, the parts are slid relatively to one another into their required positions and the wedge is again driven to clamp the parts together.—*March* 4, 1953.

Catalogues

SANDERSON BROTHERS AND NEWBOULD, Ltd., Newhall Road, Sheffield.—Leaflet "M.E.38," describing "M.C.V." steel.

NU-WAY HEATING PLANTS, Ltd., Vines Lane, Droitwich, Worcs.—Illustrated catalogue giving details of water seal stokers.

ARYN DRAWING MILLS, Ltd., 2, Pancras Street, Tottenham Court Road, London, W.C.1.—Weights list of solid drawn copper tubes.

G.W.B. ELECTRIC FURNACES, Ltd., Dibdale Works, Dudley, Worcs.—Catalogue dealing with "Autolec" electrode water heaters.

BELMOS COMPANY, Ltd., Bellshill, Lanarkshire.—Leaflet No. 101/2 describing the "SBA" flameproof air break circuit breaker.

SERVICE ELECTRIC COMPANY, Ltd., Secomak Works, Honeypot Lane, Stanmore, Middlesex.—Folder describing marine electric whistles.

EDISON SWAN ELECTRIC COMPANY, Ltd., 155, Charing Cross Road, London, W.C.2.—Publication describing Ediswan arc welding cables.

STEELS ENGINEERING PRODUCTS, Ltd., Crown Works, Sunderland.—Illustrated booklet dealing with mechanical handling in the timber industry.

HOWARD PNEUMATIC ENGINEERING COMPANY, Ltd., Fort Road, Eastbourne, Sussex.—Brochure illustrating a range of proportiometer pumps.

DAVY AND UNITED ENGINEERING COMPANY, Ltd., Park Iron Works, Sheffield, 4.—Publication No. 111, dealing with the range of Davy-United shears.

BRITISH TYRE AND RUBBER COMPANY, Ltd., Herga House, Vincent Square, London, S.W.1.—Folder giving details of the B.T.R. vibro-insulators.

E. BOYDELL AND CO., Ltd., Elsinore Road, Old Trafford, Manchester, 16.—Brochures describing the Muir-Hill "10BD" dumper and the "SS" loader.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., Telcon Works, Greenwich, London, S.E.10.—Publication entitled "Telcon Telecommunication Cables."

PRECISION COMPONENTS (BARNET), Ltd., 13, Byng Road, Barnet, Herts.—Illustrated list describing "Kabi" connector blocks and twelve-way connector strips.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Imperial Chemical House, Millbank, London, S.W.1.—Booklet giving details of "Terrabond" strip for terrazzo flooring.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

CLEVELAND INSTITUTION OF ENGINEERS

Mon., April 13th.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Acid Burdening Blast Furnace Performance at Corby," A. Stirling, 6.30 p.m.

ELECTRIC RAILWAY SOCIETY

Sat., April 11th.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, Film Show, 3 p.m.

ELECTRICAL ASSOCIATION FOR WOMEN

Wed., April 15th.—Connaught Rooms, Great Queen Street, London, W.C.2, Twentieth Annual General Meeting, 10.30 a.m.

ILLUMINATING ENGINEERING SOCIETY

Thurs., April 9th.—MANCHESTER CENTRE: N.W. Electricity Board, Town Hall Extension, Manchester, "Glass—An Old Material in a New Light," P. M. Davidson, 6 p.m.—NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, Presidential Address, W. J. Welwood.

Fri., April 10th.—HUDDERSFIELD GROUP: Electricity Showroom, Market Street, Huddersfield, Annual General Meeting, 7.15 p.m.

Mon., April 13th.—SHEFFIELD CENTRE: Medical Library, The University, Western Bank, Sheffield, "Horticultural Applications of Light," A. E. Canham, Annual General Meeting, 6.30 p.m.

Tues., April 14th.—LONDON SESSIONAL MEETING: Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Sports Lighting," M. W. Peirce, 6 p.m.

Wed., April 15th.—N. LANCASHIRE GROUP: Chamber of Commerce, 49a, Fishergate, Preston, Annual General Meeting, 7.15 p.m.

Fri., April 17th.—BIRMINGHAM CENTRE: "Regent House," St. Philip's Place, Colmore Row, Birmingham, "Discharge Lamps for Particular Purposes," E. H. Nelson, 6 p.m.

INCORPORATED PLANT ENGINEERS

Mon., April 6th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Water Engineering with Special Reference to Equipment," Gilbert Little, 7.30 p.m.

Tues., April 7th.—EDINBURGH BRANCH: Heriot Watt College, Edinburgh, "Elementary Industrial Electronics," J. H. Jones, 7 p.m.

Wed., April 8th.—E. MIDLANDS BRANCH: Welbeck Hotel, Nottingham, "Peak Steam Demands and Thermal Storage," E. G. Ritchie, 7 p.m.

Thurs., April 9th.—NEWCASTLE UPON TYNE BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Oil Injection Method of Separating and Uniting Joints on Shaft Couplings," C. S. Clarke, 7.30 p.m.

Tues., April 14th.—E. LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester, "Vibration in Buildings and Structures," Mr. DeBass, 7.15 p.m.——LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "The Maintenance of Process Plants," G. C. Allfrey, followed by Discussion, 7 p.m.

Wed., April 15th.—WESTERN BRANCH: Grand Hotel, Bristol, "The Generation of Industrial Power from Process Steam," E. G. Ritchie, 7.15 p.m.——KENT BRANCH: Bull Hotel, Rochester, "Applications of Hydraulics," D. V. Rowles, 7 p.m.

Thurs., April 16th.—BLACKBURN BRANCH: Chamber of Commerce, Richmond Terrace, Blackburn, "An Approach to Maintenance," M. Brookes, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Fri., April 10th.—TEES-SIDE BRANCH: Head Wrightson and Co., Ltd., Teesdale Ironworks, Thornaby-on-Tees, Annual General Meeting, followed by T.S.35 Film and Report, "Flow of Metal," F. Hudson, 7.30 p.m.

Sat., April 11th.—E. MIDLANDS BRANCH: College of Arts and Crafts, Derby, Annual General Meeting, followed by a Short Paper Competition, 6 p.m.——LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester, Annual General Meeting and John Wilkinson Memorial Medal Presentation, to be followed by the Winning Paper in the Short Paper Competition and "Is Mechanisation Worth While?" J. Gardom, 3 p.m.——NEWCASTLE BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, Annual General Meeting, 6 p.m.——WEST RIDING OF YORKSHIRE BRANCH: Technical College, Bradford, Prize Winning Paper in the S. W. Wise Memorial Competition, 1952–53, 6.30 p.m.

Mon., April 13th.—SHEFFIELD BRANCH: College of Commerce and Technology, Department of Engineering, Pond Street, Sheffield, "Internal Stress in Castings," M. H. Hallet, followed by Annual General Meeting, 7.30 p.m.

Tues., April 14th.—COVENTRY AND DISTRICT STUDENTS' SECTION: Technical College, Room A5, Coventry, Annual General Meeting, followed by Film Show, "Production of Castings for National Engines," "Job 99," 7.15 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

Sat., April 4th.—Christian Institute, 70, Bothwell Street, Glasgow, "Paper-work as Time Study Sees It," E. Ronalds, 10.30 a.m.

INSTITUTE OF INDUSTRIAL SUPERVISORS

Thurs., April 9th.—LONDON CENTRAL SECTION: The Polytechnic, Regent Street, London, W.1, "Relationships Between Management and Trade Unions," For Management J. G. McLeod, For the Trade Unions A. M. F. Palmer, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Thurs., April 9th.—JUNIOR SECTION DISCUSSION: 85, Minories, London, E.C.3, "So You Want to Build a Ship," 7 p.m.

Tues., April 14th.—85, Minories, London, E.C.3, "New Designs of Large Two-stroke Marine Diesel Engines," W. A. Kilchenmann, 5.30 p.m.

INSTITUTE OF PETROLEUM

Wed., April 8th.—26, Portland Place, London, W.1, "The Present Status of the Art of Cracking," W. C. Dickerman, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., April 8th.—E. MIDLANDS CENTRE: Mechanics Institute, Nottingham, "Rear Axles," R. H. Wilson, 7.30 p.m.

Thurs., April 9th.—WESTERN CENTRE: Grand Hotel, Bristol, Annual General Meeting, Film Show, 7.30 p.m.

Mon., April 13th.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Carburation," L. J. Spencer, 7.30 p.m.

Tues., April 14th.—MIDLANDS CENTRE: Crown Inn, Broad Street, Birmingham, Annual General Meeting, followed by Film Show, 7.30 p.m.

Wed., April 15th.—N.W. CENTRE: Victoria Hotel, Wigan, Centre Dinner, Annual General Meeting, followed by Social Evening, 6.30 p.m.

INSTITUTE OF WELDING

Thurs., April 9th.—S. LONDON BRANCH: Caxton Hall, Westminster, London, S.W.1, Annual General Meeting, Debate, "That This Meeting Regrets That Standardised Inspection Tests are Not Statutorily Compulsory on all Welded Work," 6.30 p.m.——LEEDS BRANCH: Lighting Service Bureau, Aire Street, Leeds, Annual General Meeting.——N.E. (TYNESIDE) BRANCH: Mining Institute, Neville Hall, Newcastle upon Tyne, "Welding of Deck-Houses," W. Muckle, 7 p.m.

Fri., April 10th.—BIRMINGHAM BRANCH: James Watt Memorial Institute, York House, Great Charles Street, Birmingham, 3, Annual General Meeting, Technical Films, 7 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., April 11th.—N.W. BRANCH: College of Technology, Manchester, "Efficiency of the Kaskade Distillation Column," F. H. Garner, S. R. M. Ellis and A. J. Hugill, 3 p.m.

Tues., April 14th.—Geological Society, Burlington House, Piccadilly, London, W.1, "The Fractionation of Liquid Air," G. G. Haselden, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Thurs., April 9th.—N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "General Developments in Sewage Works' Design," D. Johnson, 6.30 p.m.

Tues., April 14th.—STRUCTURAL AND BUILDING MEETING: Great George Street, Westminster, London, S.W.1, "The Design of a Reinforced Concrete Factory at Brynmawr, South Wales," O. N. Arup and R. S. Jenkins, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Wed., April 8th.—N. SCOTLAND SUB-CENTRE: Caledonian Hotel, Aberdeen, Centre Chairman's Address, T. S. A. Primrose, Annual General Meeting, 7.30 p.m.

Thurs., April 9th.—ORDINARY MEETING: Savoy Place, London, W.C.2, "Special Effects for Television Studio Productions," A. M. Spooner and T. Worswick, 5.30 p.m.

Mon., April 13th.—RADIO SECTION: Savoy Place, London, W.C.2, Discussion on "The Relative Merits of Broad-Band Transmission by Beam, Cable and Waveguide," opened by E. C. H. Organ, 5.30 p.m.

Tues., April 14th.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, "Digital Computers at Manchester University," T. Kilburn, G. C. Tootill, D. B. G. Edwards and B. W. Pollard, "The Construction and Operation of the Manchester University Computer," B. W. Pollard and K. Lonsdale, "Universal High-Speed Digital Computers: A Decimal Storage System," T. Kilburn and G. Ord; "Recent Advances in Cathode-Ray Tube Storage," F. C. Williams, T. Kilburn, G. N. W. Litting, D. B. G. Edwards and G. R. Hoffman, 5.30 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Inherent Current Voltage and Speed Control in Dynamo Electric Machinery," T. C. Macfarlane, J. W. Macfarlane and W. T. Macfarlane, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., April 7th.—39, Elmbank Crescent, Glasgow, Annual General Meeting, "The Fatigue Strength of Marine Shafting Part II—Large-Scale Investigation of the Effect of Fillet Radius on the Torsional Fatigue Strength of Marine Shafting," T. W. Bunyan and H. H. Attia, 7.15 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., April 15th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Running Tests of a 500 h.p. Diesel Mechanical Locomotive," B. Reed, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Thurs., April 9th.—E. MIDLANDS BRANCH: Loughborough College, Discussion on "Education and Training in Engineering Management," opened by H. G. Nelson, 7.30 p.m.

Fri., April 10th.—GENERAL MEETING ARRANGED IN CONJUNCTION WITH THE EDUCATION GROUP: Storey's Gate, St. James's Park, London, S.W.1, "The Athlone Fellowship Scheme for the Practical Training in Industry of Canadian Engineering Graduates in Great Britain," W. Abbott, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., April 7th.—LUTON GRADUATE SECTION: Peahen Hotel, London Road, St. Albans, "Standardisation and the Utilisation of Materials," E. L. Diamond, 7.30 p.m.

Thurs., April 9th.—LEICESTER SECTION: Windsor Room, Bell Hotel, Leicester, "Gear Finishing," H. Pearson, 7 p.m.——LONDON SECTION: Royal Empire Society, Northumberland Avenue, London, W.C.2, "Building a Steam Turbine," A. C. Annis, 7 p.m.——ROCHESTER AND DISTRICT SUB-SECTION: Rotary Room, Sun Hotel, Chatham, "Improvements and Their Hindrances," C. R. Whitaker, 7.30 p.m.

Fri., April 10th.—W. WALES SECTION: Central Library, Alexandra Road, Swansea, "Advanced Science and the Production Engineer," Llewellyn Jones, 7.30 p.m.

Tues., April 14th.—DUNDEE SECTION: Queen's Hotel, Dundee, "National Standardisation and Productivity," E. L. Diamond, 7.30 p.m.

Wed., April 15th.—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Contribution of Human Skills to Increased Productivity," W. D. Seymour, 7 p.m.——CORNWALL SECTION: Cornwall Technical College, Treverson Park, Poole, "The Application of Induction Heating," S. R. Tomes, 7.15 p.m.——S. ESSEX SUB-SECTION: Mid-Essex Technical College, Chelmsford, "Costing as an Aid to Management," H. H. Norcross, 7.30 p.m.

INSTITUTION OF SANITARY ENGINEERS

Tues., April 14th.—Caxton Hall, Westminster, London, S.W.1, "Cathodic Protection of Buried and Submerged Pipe-lines," K. A. Spencer, 6 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Fri., April 10th.—WESTERN COUNTIES BRANCH: Geology Lecture Theatre, The University, Bristol, Annual General Meeting, 6 p.m.

Tues., April 14th.—MIDLAND COUNTIES BRANCH: Welbeck Hotel, Nottingham, "Some Notes on Designing to B.S.449," V. H. Lawton, 7 p.m.——SCOTTISH BRANCH: Ca'doro Restaurant, Glasgow, Annual General Meeting, 6 p.m.——WALES AND MONMOUTHSHIRE BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, "Recent Developments in Timber Structures," J. R. M. Poole, 6.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., April 6th.—N.E. SECTION: Neville Hall, Mining Institute, Neville Street, Newcastle upon Tyne, Annual General Meeting, 7 p.m.

Wed., April 8th.—SOUTHAMPTON SECTION: Polygon Hotel, Southampton, Annual General Meeting and Film Evening, 7.30 p.m.

Tues., April 14th.—Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, Annual General Meeting, Films, "Basic Principles of Lubrication," "Krillium," 7 p.m.-8.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Fri., April 10th.—ORDINARY MEETING: Townsend House, Greycoat Place, London, S.W.1, "Developments in the Design of the Steam Locomotive," D. M. Hunter, 7 p.m.

Mon., April 13th.—SHEFFIELD AND DISTRICT SECTION: Livesey Clegg House, Sheffield, Film Evening, 7.30 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., April 9th.—LIVERPOOL ENGINEERING SOCIETY, The Temple, Dale Street, Liverpool, "The Basic Processes Involved in the Tempering of Plain Carbon and Low Alloy Steels," W. S. Owen, Annual General Meeting, 7 p.m.

NEWCOMEN SOCIETY

Wed., April 15th.—Science Museum, South Kensington, London, S.W.7, "A Warwickshire Windmill, and Some Notes on Early Millwrighting," "Notes on the Windmill Drawings in Smeaton's Designs," "Lincolnshire Windmills, Part I—Post Mills," Rex Wailes, 5.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., April 13th.—12, Great George Street, Westminster, London, S.W.1, "Modern Housing Construction," R. W. Wates, 5.30 p.m.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS

Wed., April 8th.—Midlands Electricity Board, Back Glebe Street, Stoke, "Gears and Their Applications," H. J. Watson, 7 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., April 15th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "The Mass Spectrometer," Winifred Hall, 6.30 p.m.